EVALUATION AND IMPROVEMENT OF EXISTING PACKAGING METHODS FOR WHOLESALE MARKETING OF TOMATO FRUITS IN GHANA.

BY

MOOMIN ABU

AUGUST, 2002

EVALUATION AND IMPROVEMENT OF EXISTING PACKAGING METHODS FOR WHOLESALE MARKETING OF TOMATO FRUITS IN GHANA

A THESIS SUBMITTED TO THE SCHOOL OF GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY (KNUST), KUMASI, GHANA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF SCIENCE (POST-HARVEST PHYSIOLOGY) DEGREE.

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ABSTRACT

Three experiments including a survey, laboratory analyses, designing and developing an improved packaging unit were conducted to evaluate and improve upon the existing packaging types and methods for marketing of tomato fruits in Ghana. The survey was carried out in four major tomato growing/marketing areas within Ashanti and Upper East Regions of Ghana. This was achieved through administering questionnaire to three sectors of the tomato industry, namely:- producers/farmers, distributors/wholesalers and retailers. Based on the survey results, two wooden crate sizes, small and big, found to be the most common packaging units for bulk distribution of fresh tomato fruits in Ghana were evaluated. Tomato fruits, transported in these two different crate sizes, from the four farm-gates (Tono, Vea, Akumadan and Agogo) to the Kumasi wholesale market, were sorted into fruits that were with slight damages, those not damaged at all, i.e., sound fruits and fruits that were completely squashed. The fruits were then analysed for ascorbic acid, pH, titratable acidity as percent citric acid, total soluble solids and reducing sugars according to crate size. In the small crates, the number of sound fruits was significantly ($P<0.05$) higher than those in the big crates. Yet, they were not effective enough to be employed in an economic venture considering the percent damage (56%) it recorded. Besides, tomato fruit quality characteristics such as pH, percent titratable acidity, percent soluble solids, percent reducing sugars and ascorbic acid contents were not significantly affected by the crate sizes evaluated. Based on the results of the survey and laboratory analyses and literature available, an improved wooden crate designed, constructed and evaluated achieved a 91% of its total fruit content by weight as sound fruits.

To the Almighty, God

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INTRODUCTION

Recent developments in agricultural technology have substantially increased the world food production in the last three decades. However, poor handling and inadequate storage facilities as well as lack of appropriate packaging techniques to suit every food type have resulted in the loss of vast quantities of food. These losses have been estimated to be more than 40-50 percent in the tropics and sub-tropics (Salunkhe *et al.,* 1991). Between the field and final consumer, large amounts of these highly nutritious crops are reduced to heaps of refuse (Kader *et al.,* 1985; Salunkhe *et al.,* 1991). Estimates of losses in developing countries for fruits and vegetables indicate very wide ranges for specific crops. For example, losses of tomato fruits varied from 20-50%; bananas, 20-80%; and papaya, 40-100%. The analysis given of the estimates indicated an overall average range of 17.7 – 32% losses in developing countries for fruits and vegetables (FAO, 1977).

Tomato fruits, egg plant fruits and yams suffer the highest post-harvest losses in Ghana (Sobotie *et al.,* 1992) and in USA tomato fruits also suffered the greatest loss during transportation from the farm - gate to the urban centres when a survey was conducted on 31 items (Handy and Pfaff, 1975). About 5-40% of fruits and vegetables produced in Ghana are lost during the various stages of the marketing process, with losses occurring at every step from harvesting to retail and sale (Gyiele, 1999). In Nigeria between 30 and 50% of fruits and vegetables produced are lost during the post-harvest period as a result of poor handling and inadequate storage facilities (Olorunda and Aboaba, 1978).

Tomato fruits are especially vulnerable to post harvest waste. Common estimates of post-harvest losses in the tropics ranged from 5-50% where losses were accentuated by improper packaging

and handling (Villareal, 1980). It was suggested that the use of simple and inexpensive packaging materials should be explored as a means to lengthen the shelf life of tomato fruits. In Ghana, estimated losses of tomato has been reported to range between 30 and 70% (Olympio *et al.*, 1998).

Fruits and vegetables are, however, gaining commercial importance due to the increasing recognition of their value in the human diet (Wills *et al.*, 1998).

Tomato is the world's widest grown vegetable crop and is second only to potato in area under cultivation and production (FAO, 1989). Its popularity among consumers stems from its nutritional value and diversity in use. In Ghana, tomato fruits are produced both during the rainy season and dry season under irrigation. It is thus cultivated widely in most parts of the country and throughout the year due to its overwhelming adaptability (Lyon and Biney, 1996).

Fresh tomato fruits are usually in short supply during the dry season - the period recommended for tomato production (Norman ,1992). This is because few farmers have access to irrigation facilities. Grown abundantly during the rainy reason, it is wasted because no modern preservation techniques exist (Kwaa, 1994) and in such times the prices are significantly low. The scarcity and abundance result in price fluctuations in the country. Meanwhile fresh tomato fruits are extensively consumed by a majority of the Ghanaian populace - almost every day in almost every household (Awiti - Kuffour *et al.*, 2000). Besides, fresh tomato fruits have export potential in Ghana (GEPC, 1995, 1998). After harvest the tomato fruits enter the local market chain, progressing from the farm-gate to the wholesale market, the retail market and finally to the consumers. However, it is one of the most perishable vegetable crops containing between 90 and 95% moisture (Tindall, 1983; Lange and Hill, 1991; Norman, 1992). Their lack of hard texture makes them bruise easily, thus spoiling within 4 – 6 days after harvest depending on the variety

among other factors, leading to huge economic losses (Olympio *et al.*, 1998). Thus the most highly adaptive methods should be used to ensure that these huge economic losses are controlled throughout the handling process. Among the means to this end available to producers, distributors and retailers, packaging is perhaps the most important.

Kwaa (1994) also conducted a survey in some Ghanaian markets and farms on the trend of fruit and vegetable packaging. It was observed that Ghana has not made progress in research on packaging of fruits and vegetables, and that the techniques that have been in existence for decades are still in use. As such, information on packaging techniques in terms of statistics is not easily available (Ellis *et al.*, 1997). Nevertheless, while highly recommended, any precautionary measures may be inadequate and even fruitless if the package selected is not appropriate to the products, distribution channels and markets concerned. In this regard, the prerequisite of remedial development is to assess the condition and trend of tomato fruit packaging and design an appropriate technology to reverse the situation.

The objectives of this work are set out with the view that it is possible to extend the shelf-life of the fruit or product by better protecting it from all the hazards it will meet while in storage and during distribution. It is also probable that sales could be increased by creating a quality image that the buyer instantly would recognize. Another fact is that, the package may appeal to the customer in terms of shape, size, colour, convenience, etc (Fellows and Axtell, 1993).

The objectives were therefore; to determine the types of packaging methods used in Ghana, to evaluate the most common packaging container used for bulk distribution, and then to develop appropriate packaging techniques for transporting and marketing tomato fruits, which would improve post-harvest practices and handling.

2.0 LITERATURE REVIEW

2.1. THE TOMATO PLANT

The tomato is a member of the potato family *Solanaceae*, belonging to the relatively small genus *Lycopersicon,* detailed accounts of which are available (Atherton and Rudich, 1986).

There are six species of tomato but only two are edible; the two are *L. esculentum* Mill., i.e, the common tomato and *L. pimpinellifolium* Mill., i.e., the cherry tomato, which is mainly used for breeding purposes (Norman, 1992). According to Tindall (1983) almost all the commercially important varieties grown in the world belong to the species *L.esculentum* Mill and that it is generally accepted that the modern tomato has been derived from an ancestral form resembling var. *cerasiforme* (Dun.) Alef.

The word "tomato" is derived from a term "tomati" used by Mexican Indians for the crop (Vickery and Vickery, 1979; Norman, 1992) and derivatives of this word have been used to describe the fruits of the crop in various parts of the world. Table 1 shows a list of names given to these fruits and the areas of origin.

Table 1: List of Names of Tomato and the Area of Origin

Name	Area of origin
Tomato, Love apple	England
Tomate, pomme d'mour	France
Tomate	Spain
Tomate	Germany
Tamatar, Vilayti, Baingan	India
Tomaat	Netherlands
Rangam, Tomat	Malaysia
Faan ke'e	China
Tomati	Nigeria
Tomati	Mexico
Jitomate	West Indies (Caribbean)
*Pomodoro	Italy
**Tomatise, Ntoos/i	Ghana

Source: Tindall (1983).
*Kumah (1998).

2.1.1. CULTIVARS GROWN IN GHANA

According to Norman (1992) tomato cultivars are generally classified by their growth habit, fruit shape, cultivation method (outdoor or greenhouse production) and whether fruit is a fresh market or a processing type, and that in West Africa cultivars may be grown either for fresh market or for processing. There are local cultivars, which evolved from varieties introduced by the Portuguese. These have poor qualities (misshapen and multiridged, poor handling and storage properties and high transport losses) but are tolerant to several diseases. Recent introductions are of better qualities but are often more susceptible to diseases (Norman, 1974).

Studies have shown that various varieties of tomato are grown in Ghana. These include Roma VF, Marglobe, Anecho, Owusu Bio, Fireball, Wosowoso, Ace VF, Floradel, Power, Caterpillar, Heinz 1250, Harvesters Supermarket, Indian River, Laurano 70, Zuarungu, Early Dwarf and Pearl Harbour (Ellis *et al.*, 1998). Others include Paul, *Noname*, Clement, Italy, Rasta, Ashanti, Pectomech, Power, Rano, Akuma, Cocoa and Money maker (Personal observation).

2.1.2. MORPHOLOGY OF TOMATO PLANTS

The tomato plant is a variable herb which can grow to a height of two metres or more (Amati *et al.*, 1995), and is a perennial which is usually grown as an annual (Norman, 1992). The tomato plant exhibits different types of growth habits, namely determinate, indeterminate and semi - determinate (Messiaen, 1992). The practice of growing tomato in many parts of South America as a perennial is well established, where the same plant is harvested for several years in succession (Amati *et al.*, 1995). It is postrate in growth. Some cultivars, however, grow errect.

The fruit is a fleshy berry with 2 - 9 loculli, orange, yellow or red when ripe; usually round, smooth or furrowed with a diameter of 2 - 5cm (Tindall, 1983) and the pigments lycopene and B-carotene are responsible for the red and yellow colours of the fruit respectively. Norman (1974) reported that tomato fruit may be shaped pear-like, globular, flattened globular or irregular with corrugations. Grierson and Kader (1986) also stated that cultivars differ greatly in fruit shape and may be spherical, oblate or pear-shaped whilst Messiaen (1992) stated that tomato fruit shape may be flat or round, smooth or ribbed, elongated or pear-shaped.

According to Garrow and James (1993) selective breeding has produced a range of tomato colours, shape and sizes and that the tomato fruit has a highly cutinized skin, which is indigestible just as the seeds are.

2.2 USES OF TOMATO FRUITS

The tomato crop is grown for both fresh market and processing. Tomato fruits are used in a variety of ways; in either the cooked or raw state. Tindall (1983) stated that processing cultivars are used for the production of purees, juices, canned fruits and sauces. Blanchfield (1967) also earlier on stated that processed tomato concentrate is used in other parts of the world to prepare products including tomato ketchup, canned and dehydrated tomato, bottled tomato juice and canned beans in tomato sauce. The colour, distinctive flavour and pleasing acid taste in the fresh, canned or preserved state have made the fruit valuable. Hence the statement by Anorld (1986) that the distinct flavour is recognized as ideal to enhance dishes based on meat, poultry, fish, cheese, eggs, rice, paste and other vegetables. In West Africa e.g. Ghana, tomato fruits are used mainly in stews, soups,

sauces and eaten raw in salads. Canned juice, puree, pickles and other products are also popular in the country (Norman, 1992).

At present there is very limited processing of tomato fruits in Ghana due to the defunct nature of the only two tomato canneries at Pwalugu and Wenchi which were established in 1968 and 1973 respectively.

Awiti-Kuffour (1997) indicated that there is powdered tomato in the Ghanaian market alleged to have come from the north and neighbouring Cote D'Ivoire, but that it is of low quality, usually adulterated and mainly used by the cooked food sellers as it gives good colour to stews. The author added that the migrants from the northern sector to the south reported that they had occasionally used sun-dried tomato fruits for home consumption and not undertaken as a business. However, Nicol *et al.* (1997) demonstrated how to improve tomato powder production.

Tomato fruits can also be processed into "shito" a chilli and fish/shrimp based pickle. This is usually done at the household level although now local manufacturers produce it for sale, for its popularity among students studying away from home. However, many manufacturers prefer to use imported puree rather than the fresh tomato fruits which require more processing and have a shorter shelf-life (IFCSP, 1996). Tomato seeds contain about 24% edible oil – used as salad oil, in the manufacture of margarine and soap, as livestock feed and as fertilizer source (Tindall, 1983).

Schurman (1967) stated that consumption of tomato concentrate rises each year in Ghana during the off-season when fresh tomato fruits are scarce. Reysse (1968) and MaClean (1970) stated that tomato concentrate has better market prospects than any other fruit or

vegetable canned in Ghana. It was estimated then that the demand for tomato concentrate was about 3200 metric tonnes, which was projected to increase by 3% annually. Thus by the year 2010, demand is expected to reach over 7000 metric tonnes (Anonymous, 1995). To meet this demand, the Government imported about 675 metric tonnes of tomato concentrate in 1992. Imports rose to 2870 metric tonnes in 1993 and 3110 metric tonnes in 1994. However, the tomato fruit is not without export potential in Ghana. Between January and December 1994 and 1995, a total of 14720 metric tonnes of fresh tomato fruits was exported. This earned the nation US $ 6,611.04 which was a contribution of about 0.02% of the non - traditional exports (GEPC, 1995). From January to December 1997, a total of 816,494 metric tonnes of fresh tomato fruits was exported, earning the nation US $ 149530.75 as a contribution of about 0.26% to the total export performance of non-traditional products for the period (GEPC, 1998).

2.3. TOMATO FRUIT QUALITY

Swiader *et al.* (1992) stated that the quality of fresh fruit is combination of characteristics, attributes and properties that give a commodity value to humans for food. The connotation is that the important attributes of quality vary according to the individual(s) defining the term. The authors indicated that: growers are interested in disease resistance, high yielding, uniform maturity, desirable size and ease of harvest. Post-harvest characteristics have not been one of their main interests; shippers and handlers are concerned with shipping quality and market quality. Firm fruit that can endure inexpensive handling and transport and still maintain high market quality is desirable; consumers care about appearance, price, and table quality, including texture, flavour, colour, and nutritive value. Villareal (1980) earlier on stated that an effective quality control system through out the handling steps between harvest and retail display is

essential to providing a consistently good-quality supply of fresh fruit to the consumer and to protecting the reputation of a given marketing label.

2.3.1. CHEMICAL COMPOSITION AND NUTRITIVE VALUE

The moisture content of immature green tomato fruits increase from about 91% to 93% as the fruit develops (Davies and Hobson, 1981). The authors also reported that good quality ripe fruits have an average moisture content of 94 - 94.5%, the range being 92.5 - 95%. Thus fresh tomato fruit has a high water content which accounts for its high perishability.

Bajaj *et al.* (1987) reported that the mean dry matter content of different varieties of tomato fruits was found to be 4.61 – 7.37% at maturity and that 39% of the dry matter is carbon (Ho *et al.*, 1983). Davies and Hobson (1981) also indicated that more than 90% of the total mineral content of the tomato fruit consist of potassium, nitrogen and phosphorus. Wills *et al.* (1998) stated the sugar content (g/100g fresh weight) of fresh tomato fruit as, one for glucose, one for fructose, and zero for sucrose; where zero indicates <0.1g/100g present. The sugars, mainly glucose and fructose, which form 3.5% of fresh weight at ripening (Ho and Hewitt, 1986) account for about half of dry matter of 65% of total soluble solids (Winsor, 1966).

Bajaj *et al.* (1987) also found that the total soluble solids of tomato fruit range from 3.8 – 5.6 °Brix. Ho and Hewitt (1986) reported that the starch content is about 1% dry matter at the mature green stage or 0.03% fresh weight at ripening. The authors further added that pH of sap of fruit at mature green is about 4.0 and the organic acids (mainly citric and malic acids) make up about 13% of dry matter. The mean ascorbic acid content

(mg/100ml juice) varies from 10.44 - 22.10 and the mean lycopene content is 1.95 - 6.77 mg/100g on fresh weight basis (Bajaj *et al.*, 1987).

Grierson and Kader (1986) also reported that there are more than 200 individual volatile constituents (mainly esters, alcohols, acids and carbonyl compounds such as aldehydes and ketones etc) in the tomato fruit but that they have not been fully understood. On comparing tomato fruit to orange fruit, Kochlar (1986) found that tomato fruits contained nearly 20 times as much vitamin A, the same amount of vitamin B1, slightly more vitamin B2 and over 2/3 of vitamin C. Grierson and Kader (1986) also found that 20% of vitamin A and 40% of vitamin C required (daily) by an adult, can be supplied by 100g tomato fruit. According to Rick (1978) tomato fruits rank first in the contribution of vitamins and minerals to diets in the U.S.A. Table 2 shows the nutritional composition of the tomato fruit (raw, canned, and juice).

Table 2: Nutritive values of 100g edible portion of raw and processed tomato fruits

Nutrient	Raw	Canned	Juice
Water %	94	94	94
Food energy (cal)	19	21	19
Protein (g)	0.7	0.8	0.8
Fat (g)	trace	trace	trace
Carbohydrate (g)	4	4	4
Calcium (mg)	12	6	7
Phosphorus (mg)	24	19	18
Iron (mg)	0.4	0.5	0.9
Potassium (mg)	222	217	227
Vitamin A value (iu)	822	900	798
Thiamine (mg)	0.05	0.05	0.05
Riboflavin (mg)	0.04	0.03	0.03
Niacin (mg)	0.7	0.7	0.8
Ascorbic acid (mg)	21	17	16

Source: USDA Home and Garden Bulletin, No. 72. 1980.

2.3.2. QUALITY COMPONENTS

Wills *et al.* (1998) stated that important quality components for producers, distributors and consumers are appearance including size, colour, shape, condition (such as freshness) and absence of defects; texture and firmness; flavour, and nutritive value.

2.3.2.1. APPEARANCE

A rapid visual assessment of the tomato fruit appearance can be made on the basis of size, shape, colour, condition and or the presence of defects or blemishes and rot as indicated by Wills *et al.* (1998).

Atherton and Rudich (1986) stated that freshness, stage of senescence or ripeness, the extent of mechanical damage and pest or disease incidence detract from appearance and in most markets detract from price, even when the blemishes reduce neither keeping quality nor eating quality. Evaluation of defects (Table 3) is only subjective since there are no objective ways of evaluation (Atherton and Rudich, 1986). This inspired Grierson and Kader (1986) to develop a subjective rating scale for tomato fruits as in Table 3. According to Grierson and Kader (1986) a very serious defect which makes the fruit unmarketable is the presence of rot and that this may be caused by pathogen invasion due to some physical damage during harvest and post harvest handling stages.

Among these factors which influence visual appearance, Arthey (1975) confirmed that colour measurements in fresh and processed fruits and vegetables and other foods are without doubt the most important single quality factor that affects grower-processor relationship and consumer acceptance of products. Thus appearance is a major determinant of quality, especially because it is often the only criterion available to the buyer of the commodity.

Table 3: Description of Grades for Tomato Fruit Quality Assessment

Grade.	Description .
Excellent.	Essentially no symptoms of deterioration.
Good.	Minor symptoms of deterioration, not objectionable.
Fair.	Deterioration evident, but not serious.
Poor.	Serious deterioration, limit of salability.
Extremely poor.	Not salable.

After Grierson and Kader (1986).

2.3.2.2. FIRMNESS

According to Atherton and Rudich (1986) firmness is closely related to stage of ripeness of tomato fruits. The authors added that sensory evaluation of tomato fruit textural quality involving finger feel, mouth feel and slicing characteristics are all related to firmness. Beattie *et al.*(1983) indicated earlier that firm fruits (tough skin and firm flesh) are less susceptible to physical and mechanical damage, and therefore store better and enhance transportation and distribution in the marketing system. Atherton and Rudich (1986) also stated that for successful mechanization of the tomato industry, the most important characteristic is a concentrated set of firm, tough fruits. However, fruit firmness according to El-Sayed and Erickson (1966) has been found to be under genetic control.

2.3.2.3. FLAVOUR

Kader *et al.* (1985) indicated that flavour is comprised of taste and aroma and that the aromas of many chemical constituents are responsible for the flavour of tomato fruits when tasted. Wills *et al.* (1998) stated that the taste of fruit and vegetables is usually a blend or balance of sweet and sour, often with overtones of bitterness due to tannins. The sweetness, sourness and overall flavour intensity in fruits according to Debruyn *et al.*

(1977), are influenced by sugars, acids and their interactions; and Davies and Hobson (1981) testifies that fructose and citric acid are more important to sweetness and sourness than glucose and malic acid respectively.

High sugars and relatively high acids give best flavour. High acids and low sugars produce tart (unpleasant sharp taste) tomato while low acids and high sugars give bland (mild in flavour, not having interesting taste) taste. Low acids and low sugars give tasteless, insipid tomato fruits (Grierson and Kader 1986).

Tomato cultivars which have large locular portions and high concentrations of acids and sugars have better flavour than those with smaller locular portions (Stevens *et al.*, 1977). Volatile compounds are important to the development of aroma as well as the overall flavour of tomato fruits (Kader *et al.*, 1985). Hayase *et al.* (1984) indicated that out of the 130 volatile compounds identified, hexanal trans-2-hexanal, 2-isobutyl-thiazole, 2-methyl-2-hepto-6-1, geranylacetone and farnesylacetone were found to be the most important contributors to fresh tomato fruit aroma, and that their concentration increased with ripening. Galliard and Mathew (1977) found out that the oxidative breakdown of linoleic and linolenic acids by the action of lipoxygenase and many other intermediate reactions and products also contribute to flavour in the tomato fruit. Grierson and Kader (1986) however, concluded that off-flavours found in certain tomato cultivars appear to be related to higher concentrations of certain volatiles especially 2-methyl-1-butanol which has a flavour threshold concentration of 0.1 to 1.0 ppm.

2.4 FRESH MARKET QUALITY REQUIREMENTS

Villareal (1980) indicated that the major outlets for the fresh - market tomato fruits are the wholesale markets and retailers and that tomato fruits for the fresh market are harvested at various ripening or colour stages. The availability and cost of labour, distance to market, intended use, and factory capacities all influence the manner and number of harvests. Norman (1992) stated that the fresh tomato fruits are usually packaged in baskets, cardboard boxes, wooden crates or tins and transported by train or road in trucks and other transport-means over long distances (up to 1200 km in Nigeria and 800km in Ghana) in capacities of 10-30kg. According to Villareal (1980) fresh market tomato fruits are expected to be firm, whole and healthy, of good keeping quality and evenly coloured.

Atherton and Rudich (1986) stated that most consumers prefer the deep uniform red coloured tomato fruits and that they also prefer firm fruits which do not lose too much juice when sliced and which do not have tough skin. Grierson and Kader (1986) indicated that the textural quality of tomato fruits is influenced by skin toughness, flesh firmness and internal fruit structure (pericarp/locular material ratio) and that these factors vary greatly among cultivars.

Thompson (1996) stated that irrespective of recommended temperature and relative humidity conditions, fruit shelf-life or good keeping quality can be affected by so many other factors which are especially related to the conditions in which the crop was grown, the harvest maturity, the crop cultivar and the conditions in which the crop has been kept between harvest and storage. In some cases shelf-life is given at marketing temperatures where some markets prefer "breaker" fruits which are partly green and others prefer

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entirely ripe fruit. Tindall (1983) reported that at 2°C temperature and 85-90% relative humidity (RH), the shelf-life of ripe tomato fruits was found to be 40 days; at 10°C and 85-90% RH, the fruits stored for 35 days; and whilst at 21°C and 85-90% RH, the fruits stored for 21 days only. In another development, Snowdon (1991) noted that shelf-life studies on mature-green, turning and ripe tomato fruits gave the following results: for mature green fruits, 12-15°C and 90% RH fruits lasted 1-2 weeks; turning fruits can be stored at 10-12°C and 90% RH for 1-2 weeks; and ripe fruits may be stored at 8-10°C and 90% RH for 1 week. Blay and Aflakpui (1985) studied shelf-life of tomato fruits under ambient conditions (24-27°C) and reported 11-32 days range for the fruits.

Notwithstanding the impact of the various shelf-life studies indicated, wastage of fresh tomato fruits by micro-organisms between harvest and consumption can be rapid and severe particularly in tropical areas where high temperatures and high humidity favour rapid microbial growth. Further more, ethylene emitted by rotting produce can cause pre-mature ripening and senescence of other produce in the same storage and transport environment, and sound produce can be contaminated by rotting produce (Atherton and Rudich, 1986). Apart from actual losses due to wastage, further economic losses occur if the market requirements necessitate sorting and repacking of partially contaminated consignments (Swiader *et al.*, 1992).

2.5 QUALITY REQUIREMENTS FOR THE PROCESSING INDUSTRY

According to Villareal (1980) quality requirements for processing tomato fruits are specific: high contents of solids (at least 4.5°Brix), low pH (about 4.4), firmness, easy peeling, crack resistance, excellent red colour, little or no fibrous core, small blossom-end closure and stem-end scar. She further explained that maintaining high levels of solids,

however, has been a problem because as yields increase the solids percentage decreases. Furthermore a pH higher than 4.5 is undesirable because it increases problems with thermophilic organisms, making it difficult to get a safe produce with normal processing techniques. Villareal also indicated that firm fruits reduce damage during transit and explained the need for easy picking, crack resistant fruits, colour and other market appeal factors.

Gould (1983) indicated that among other processing qualities for the tomato fruit, high acid content (minimum of 0.35 and up to 0.55%) and high vitamin C content (minimum of 20mg per 100g) was required. Norman (1992) also stated that high content of reducing sugars and high pulp content among other processing qualities were desirable. It is reported by Tressler and Joslyn (1970) that total soluble solid content of 6.8 - 7.0, acidity of 0.6 - 0.7 and pH of 4.2 - 4.4 are an indicator of high tomato fruit quality. However, a reduced water content and related increase in soluble solids concentration is desirable in processing tomato fruits, where paste production is the objective (Kordylas, 1991).

Davies and Hobson (1981) reported that the soluble carbohydrates of the fruits of commercial varieties of tomato are almost entirely reducing sugars. The authors also reported that since the sugars constitute 1.5 - 4.5% of the fresh weight, equivalent to some 65% of the total soluble solids, they have an important effect on the taste of the ripe fruit. De Bruyn *et al.* (1977) also reported that the free sugars consist of glucose and fructose present in approximately equal amounts with a slight preponderance of the latter; sucrose, when found at all, rarely exceeds 0.1% of the fresh weight, and that traces of other sugars have been reported, notably ketoheptose and raffinose.

The total soluble solids content of tomato fruit is important both from the stand point of product consistency and processing, as well as the quality of the fresh produce (Gould,1983). Opena (1983) indicated that high value of total soluble solids is desirable because it relates to the yield of processed products.

Lambeth *et al.* (1966) indicated that there is a tremendous variation among tomato genotypes for pH and titratable acidity. In a study of 250 tomato accessions they found out a variation in pH from 4.26 – 4.82 and percentage citric acid ranged from 0.40 – 0.91% for *Lycopersicon esculentum* accessions. They also emphasized that the acids of tomato fruit have been the subject of considerable investigation, not only are they important as major taste components, but they also play important roles in the satisfactory processing of tomato products. Sakiyama and Stevens (1976) stated that the predominant acid of ripe tomato fruit is citric with malic the next most abundant. Other acids reported earlier include formic, acetic, and trans-aconitic acid with traces of lactic and fumaric acids in processed tomato products (Bradley, 1972).

Salunkhe *et al.* (1991) reported that one of the most important factors affecting the sterilization times and temperature in the canning of tomato fruit is the actual pH of the food. Thus the lower the pH value (high acidity), the lower the degree of heat required for sterilization. Aworh *et al.* (1982) also reported that low pH is a desirable quality characteristic in tomato fruits because of its importance in processing, as it reduces contamination by *Clostridium botulinum* (bacterial) spores. According to Gould (1983), factors believed to have effect on the actual pH values of tomato fruits are cultivar, maturity, seasonal variation due to growing conditions, geographical areas, handling and holding practices.

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The retention of ascorbic acid as an index of quality and nutritive value in fruit and vegetable processing and the associated rapid loss (Krochta *et al.*, 1975) cannot be over emphasized. Hence the need for its proper handling and restoration. Salunkhe *et al.* (1991) stated that loss of ascorbic acid can occur during storage in the raw state. The authors added that losses are accelerated by high temperatures and high rates of wilting. Further they stated that bruising and mechanical damage greatly increase the rate of loss of ascorbic acid because it is highly susceptible to oxidation, either directly or through an enzyme (ascorbic acid oxidase) which is widely distributed in plant tissues. Bradley (1972) earlier on reported that the rate of ascorbic acid degradation is affected by pH, temperature, oxygen availability and the vitamin concentration. It's degradation is retarded significantly in sugar solutions.

2.6. PACKAGING

Salunkhe *et al.* (1991) indicated that modern packaging has significantly contributed to improved handling and transportation of fresh fruits and vegetables between growers and consumers. Improvement in packaging technology have contributed greatly to more efficient marketing of fresh fruits and vegetables. Consumers now receive these commodities in fresher condition with less damage and more potential shelf-life with greater appeal and convenience than ever before because of packaging research and development (Amuttiratana and Passornsiri, 1992). Pantastico (1975) stated earlier that for many centuries, non-existent or inadequate facilities for transportation, refrigeration and packaging prohibited wide distribution of perishable foods and that produce had to be consumed locally in season, and receive only crude bulk packaging with little concern for sanitation or protection of quality. He added that even in undeveloped countries growers

are now beginning to market their produce through co-operatives, allowing use of more modern warehouse facilities for grading and packing products before distribution.

Under the competitive system of marketing, improved procedures such as modified atmosphere packaging (MAP) and controlled atmosphere storage (CAS) (Elworthy *et al*., 1989), coupled with the availability of refrigerated vans and use of appropriate barrier films such as Pro-long (Quantick and Motlagh, 1988; Dhalla and Hanson,1988), wax emulsions (Mitra, 1997) and absorbent techniques (Wills *et al*., 1998) soon are widely adopted. Boyette *et al.* (1996) however, stated that packaging requirements vary widely depending upon the commodity to be packaged and on the conditions which the produce will meet from the farm packer, wholesaler and retailer to the consumer.

However, packaging alone cannot improve quality. Therefore, only the best possible produce should be packaged. Inclusion of rotten or damaged produce in bulk or consumer packages may prevent sale at the market, or become a source of contamination or infection to healthy produce (Pantastico, 1975). He added that packaging is not a substitute for refrigeration; quality maintenance will be best when good packaging is combined with refrigerated storage or transport.

Wills *et al*. (1998) reported that the importance of packaging as a determinant of final (consumer level) product quality is largely underrated. Meanwhile, centers of consumption of fresh produce are usually remote from production areas. Accordingly, the allied costs of distribution which induce handling, packaging and transportation often exceed those of production in both economic and energy terms(Wills *et al*., 1998). Villareal (1980) stated that careful management of the distribution system will ensure that produce retains its quality and maximizes economic returns. She also indicated that

maximum benefits can be realised from the production of fresh fruits and vegetables through the reduction of losses between harvesting and consumption. Losses could occur as a decrease in quality and or quantity and could as well be attributable to improper handling practises resulting from inappropriate packaging. According to Wills *et al.* (1981) packaging has been practised for as long as fresh produce has been traded.

2.6.1. FACTORS AFFECTING PACKAGING UNITS

According to Paine (1987) factors affecting packaging units in transit and storage include climatic, mechanical, biological and other hazards. Bonte-Friedheim (1989) stated that some of the hazards are unavoidable (environmental) which make physical protection by way of packaging essential, while others are introduced by man through his working practises (pilferage, chemical treatments etc). However, improvements in these practices may be more economic than the provision of packaging of some sort to resist their effects.

2.6.1.1. CLIMATIC HAZARDS

Arthey and Dennis (1991) stated that the rate of package development is constantly accelerating and the more critical environmental climate leads to different approaches being made towards the re-use or disposal of the package itself. They indicated that the climatic factors that affect packaging of fresh tomato fruits include moisture, temperature, relative humidity and light.

2.6.1.1.1. Moisture

Experiments conducted by Hardenberg *et al.* (1990) have shown that fresh fruits and vegetables contain a high percentage of moisture and some of this moisture is deposited on the internal surface of the packaging unit through respiration and evaporation from

their surfaces. According to the authors, the tiny films of the water droplets on the internal surface of the package can cause damage depending on the package's susceptibility to moisture conditions. Also, a high moisture concentration on the internal surface of the package serves as a breeding ground for harmful biological organisms such as moulds and bacteria.

2.6.1.1.2. Temperature

Wills *et al.* (1981) reported that there is no specific ideal temperature for the storage of both packaged and unpackaged fruits and vegetables because their responses to reduced temperatures which aid in extending their shelf-lives vary widely. They reiterated that the importance of factors such as mould growth, chilling injury and the required length of storage must be taken into account. The high temperatures which are typical of tropical regions encourage a rapid rate of deterioration in fresh fruit which continue to be metabolically active after harvest. Thus the optimum storage temperature for a particular produce in any given locality is determined from trials with locally grown produce because climatic and soil factors may influence storage responses (Lieberman, 1983). However, the individual can rarely undertake even the most elementary precautions against fresh tomato produce deterioration through high temperatures, except by harvesting when produce temperatures are at their lowest (i.e., optimum storage temperatures) and holding the produce under protected (use of appropriate containers) and ventilated conditions or, at least under shade (Tindall and Proctor, 1980).

2.6.1.1.3. Relative Humidity

Increasing relative humidity around packaged fruits enhances the preservation of quality as a result of a decrease in the rate of evaporation from the produce (Thompson, 1996). However, storage at a high relative humidity may pre-dispose produce to infection by micro-organisms which can cause rot (Tindall, 1983). Other studies conducted by Wills *et al.* (1981) showed that growth of these organisms is reduced when the relative humidity is between 85 and 95 percent and for leafy and some root vegetables, 98 -100%. Thus a compromise has to be reached between the provision of adequate air movement by ventilation and the required relative humidity.

2.6.1.1.4. Light

Investigations conducted by Lieberman (1983) have shown that one of the major factors contributing to deterioration of packaged fresh fruit is the treatment it receives immediately after harvesting such as exposure to the potentially adverse effects of the sun. Hardenberg *et al.* (1990) showed that gamma radiation can be used to control rot, disinfestations and extend the storage and shelf-life of fresh fruits and vegetables. On the other hand, commercial application of gamma radiation is limited due to the cost and size of equipment needed for the treatment and also whether irradiated foods will easily be accepted by the customers or consumers. The authors also found out that although ultraviolet light has a lethal effect on bacteria and fungi that are sufficiently exposed to direct rays, there is no evidence that it reduces rotting of packaged fruits and vegetables.

2.6.1.2 MECHANICAL HAZARDS

Fruits and vegetables are liable to certain types of mechanical damage such as bruising, abrasion etc., but very perishable fresh produce like tomato fruits are more vulnerable (Villareal, 1980) due to their sensitivity to the hazards associated with inappropriate containers used during routine harvesting, handling, transport and storage (Gould, 1983). The injuries serve as an avenue for infection (Brennan *et al.* 1990), increase respiration and hence increase the rate of deterioration leading to loss of edible material because of the need to trim off damage portions.

2.6.1.3. BIOLOGICAL HAZARDS

Coursey and Booth (1972) stated that diseases due to fungi, bacteria and viruses may account for a considerable proportion of the total post - harvest loss in packaged tomato fruits and these organisms especially fungi and bacteria may be present in the package or container prior to produce-filling or on the tissues of the produce prior to harvesting. They indicated that the initial infection may be a direct result of mechanical damage and is likely to be rapidly followed by a massive infection of a broad spectrum of non-specific saprophytes which enhance the damage done. These secondary invaders thus play a major role in post harvest pathology by multiplying and extending the damage initiated by the primary pathogens. Insect (wood-boring insects like termites) damage is likely to result in direct loss than injury caused by pathogens, but the external and internal invasion of tissues by larvae which developed from eggs laid in or on the produce prior to harvesting may result in unsightly or unmarketable produce.

2.6.2 CHARACTERISTICS OF PACKAGING

Part of the post - harvest losses of fresh produce in less developed regions are a result of mechanical injuries due to poor handling and inadequate packaging (Schuur, 1988). The author added that in more developed marketing systems packages serve also other objectives such as market penetration and competitiveness. Proper packaging of a product can reduce not only bruising and crushing but can also improve marketing of produce, reduce moisture loss, prevent (re-)contamination of the product with spoilage organisms, reduce pilferage and maintain a sanitary environment during marketing (Arthey and Dennis, 1991).

Buel (1986) stated that all aspects of packaging must be taken into account when considering the introduction of new packaging and these aspects involve, among others, cost of packaging material, labour, acceptance by trader and consumers and changes in produce condition. He added that in any case the ultimate goal of packaging must lead to easier handling of the produce, a better quality and better marketable product.

Boyette *et al.* (1996) stated that a significant percentage of produce buyers' and consumers' complains may be traced to container failure because of poor design and inappropriate selection and use. A properly designed produce container should contain, protect and identify the produce, satisfying every one from grower to consumer.

Schuur (1988) outlined the characteristics of packaging that they are to contain, protect, communicate and to market the product. Mitra (1997) also indicated that there are various advantageous attributes to be considered when selecting a particular type of container. He reiterated that it should be easily transported when empty and occupy less space than

when full. For example, plastic boxes which nest in each other when empty, collapsible cardboard boxes, etc; it must be easy to assemble, fill and close either by hand or by use of a simple machine. Further, the container should be designed to meet the product requirements for ventilation or other operations such as fumigation or inspection. It should also be designed to suit the transport system (correct dimensions to allow stacking on pallets) and to meet specific market requirements in terms of presentation and capacity. The package should be recyclable or recoverable or re-usable in some form and it must be cost effective in relation to the market value of the commodity for which it is used. A good package must be readily available, preferably from more than one person or from a reliable supplier at an acceptable cost.

2.6.3. TYPES OF CONTAINERS AND PACKAGING MATERIALS

Boyette *et al.* (1996) stated that bags, crates, hampers, baskets, cartons, bulk bins and palletized containers among others, are convenient for handling, transporting and marketing fresh produce. They reported that more than 1500 different types of package are used for produce packaging in the USA and the number continues to increase as the industry introduces new packaging materials and concepts. The industry generally agrees that container standardization is one way to reduce cost. Thus the trend in recent years has moved towards a wider range of package sizes to accommodate the diverse needs of wholesalers, consumers, food services buyers and processing operations. However, it is not practical to recommend specific packages for each fruit or vegetable, as several types may be satisfactory.

The most suitable package would depend on factors including the region, environmental conditions, length and nature of the market chain, methods of handling and transport,

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availability and cost of materials and whether the produce is to be refrigerated (Pierce, 1987). For example tomato fruits, leafy greens, lettuce, melons, pepper, cucumber, cauliflower, cabbage, etc may be transported in baskets, nailed crates, wirebound crates or fibreboard cartons (Wills *et al.*, 1998). Just as there are many different types of package in use throughout the world, many of them have often been adopted for general use without thorough evaluation (Boyette *et al.*, 1996).

2.6.3.1. MODERN PACKAGING

Modern packaging of fruits and vegetables is mainly practiced in the developed countries. With specific and technological developments, various kinds of materials are used to manufacture these packages while ensuring that both the quality and quantity of the produce are maintained (Hanlon, 1992). Hanlon indicated that some of the materials used for construction of these packages include wood, fibreboard, plastics, paper, pulp, polythene or burlap. Recent modern packaging include modified atmosphere packaging (MAP), controlled atmosphere storage (CAS) and the absorbent techniques (Wills *et al.*, 1998).

2.6.3.1.1. Wooden Crates

Wooden crates commonly used include the nailed crates, stitched crates, wire bound crates and wooden collapsible crates (Harvey, 1986). The author indicated that the advantages of wooden crates are: the crate can be manufactured and repaired locally; wood is relatively resistant to different weather conditions; wooden crates are often used on more than one journey and have a higher efficiency for large fruits e.g. water melon; most wooden crates have good ventilation and fast pre-cooling is possible. On the other hand, the disadvantages of wooden crates have been outlined as follows: untreated wood

can easily become contaminated with fungi and bacteria; treatment of wooden crates with paint or other chemicals may cause produce deterioration; the material may be too hard or rough for produce like tomato fruits (very soft) and therefore, liners of a soft material may be needed; disposal of the crates after use; manufacturing of wooden crates put an extra claim on the natural forest resource (Anon 1993).

The wooden crate is sturdy and gives good protection, but careful handling during filling and emptying is important. The depth of filling affects the amount of damage (Ryall and Lipton ,1972).

Nailed Crates: Nailed wooden crates are rigid and strong boxes which serve as multi-trip containers with a long life time and are frequently used for domestic transport e.g. as a field crate or as a crate to transport produce from the producer to the wholesaler or trader(ITC/UNCTAD/GATT,1988). Water has no direct influence on the strength of the crate, but rot will (Schuur, 1988). An advantage of the nailed crate is the possibility to repair the crate while the disadvantages include the high return volume (ITC/UNCTAD/GATT,1988).

Stitched Crates : According to Schuur (1988) stitched wooden crates are normally used for tomato fruits and that they are mainly for single journeys.

Wire-bound Crates: It has been indicated that wire bound crates are normally used for tomato, orange, grape fruit, potato, etc and that as a rigid, cheap crate with a good stacking strength it is mainly used for single journeys (Anonymous, 1982). The wire-bound crates provide good ventilation and fast pre-cooling is possible as well as good drainage if the package is hydro-cooled.

Wooden Collapsible Crate: FAO (1989) report indicated that the crate can be folded using the hinges on the corners and that it is possible to make up to 12 trips using the same crate.

6.3.1.2. Fibreboard Boxes

Fibreboard boxes are frequently used because of their low weight, their range of sizes and shapes, and their availability (Anonymous, 1992). The author(s) described two types of fibreboard boxes as being solid and corrugated fibre boxes. Solid fibreboard boxes or cartons have a thickness between 0.85 and 3mm. If treated with wax, these boxes are reasonably moisture-resistant and are used for tomato, cucumber and ginger transport. Corrugated fibreboard boxes usually have a thickness varying from 1.2 up to 8mm.

The advantages of fibreboard boxes as stated by Lott (1977) are: low weight and easy to handle; the relatively soft walls have a cushioning effect; the box can have any design, although it is recommended to use sizes fitting on the standard design of pallets; the boxes are delivered flat and assembling boxes can be done locally; the box has a low purchase cost; the material can be printed to give the box a pleasant and recognizable appearance – also the label can be included in the print. Lott stated the following as the disadvantages: - moisture and high humidity can seriously weaken the box; the low rigidity causes the stacking strength to be lower than for wooden or plastic crates; ventilation holes are usually small, because large holes would seriously influence the strength of the box; the boxes are not re-usable.

.6.3.1.3. Plastic Crates

Schuur (1988) indicated that plastic crates are more expensive than wooden crates and carton boxes, but as a result of their longer lifespan the running costs are relatively low. However, the possibility of pilferage of the crates should be taken into account when considering purchase of the type. The author, however, emphasized that the hard surfaces have no cushioning effects, but a hard, smooth surface is easy to clean and gives good protection to the produce.

A study in Thailand showed that a plastic crate, while costing five times as much as a traditional bamboo basket of similar capacity, was still useful after 20 times the number of journeys, putting the cost per journey of the plastic crate at about one-quarter of that of the bamboo basket (Bonte-Friedheim, 1989). The other advantages of the plastic crates found were that different sizes and shapes were available to suit different customers' needs. Besides they were easy to clean, disinfect, and were strong and weather-resistant (Briston,1980). Because of their water resistance, the containers could be used in humid areas and during hydro -cooling. According to the author the disadvantages observed were that: the hard surfaces could damage the produce, the high purchase cost combined with the risk of pilferage could make this type of crate a financial risk. Generally, plastic crates have to be imported and because it can be used several times, the extra cost for the return trip should be included in the total running cost (Schuur, 1988). Plastic crates can have a stacking, a stack-nest or a collapsible design, the difference being particularly important when the crate is transported empty, since the volume determines the price to be paid for transport.

.6.3.1.4. Pallet Boxes

Stokes (1974) reported that where conditions like the size of the field, the method of harvesting, the level of processing and packaging, and the commodity allows better transport and storage, a higher efficiency can be reached by using pallet boxes. Pallet boxes have the standard floor size of a pallet (1200 x 1000mm) and depending on the commodity, have standard height (Anonymous, 1993). According to the author(s) the advantages of a pallet box system are: less manual handling and thus reduce cost in loading, filling and unloading; more efficient use of available storage as compared to smaller crates; and increased speed of mechanical harvest. The author(s) also outlined the disadvantages of the pallet box system as follows: the return volume of most of the pallet boxes is the same as the full load; the system requires higher investments in fork-lift trucks, trailers and handling systems to empty the pallet box; because of the larger volumes, the produce is more easily injured during filling and unloading and the top layers would have made more movements during transport than when packed in smaller boxes.

.6.3.1.5. Sacks and Nets/Bags

The materials used for sacks and nets or bags may be woven natural fibre (jute, kenaf, sisal, cotton), woven synthetic (polypropylene, polyethylene), knitted natural fibre (cotton), knitted synthetic (polyethylene), or non-woven synthetic (propylene) (FAO,1989). Bags usually refer to small containers of up to about 5kg capacity. They may be woven to a close texture or made in net form. Nets on the other hand usually have a capacity of about 15kg.

The advantages of using sacks and nets are merely financial (Schuur, 1988). This is because the sacks and nets are cheap, have a low weight/volume ratio, and if made of a

synthetic material, will not rot. He however indicated that the disadvantages include a low protection against puncturing, compression, vibration and impact injuries from dropping and stacking, a low rate of vapour transmission and the need for special stitching equipment. In general nets are only suitable for hard produce as coconuts and root crops such as potato and onions, but even these crops should have careful handling to prevent injury (Bonte-Friedheim,1989).

2.6.3.1.6. Plastic Film Bags

Plastic film bags or wraps are, because of their low cost, widely used in fruit and vegetable marketing especially in consumer-size packs (Pantastico, 1975). From the findings of Bonte-Friedheim (1989), consumer packs wrapped in plastic films are not recommended under tropical conditions even with perforations for ventilation except perhaps in stores with refrigerated displayed cabinets. This is because they cause a rapid build up of heat if bags are exposed to sunlight. Even though they retain water vapour thus reducing water loss from the contents, when temperature changes occur, they cause a heavy build up of condensation leading to rot. Plastic film bags permit only slow gas exchange, this combined with vapour and heat leads to very rapid deterioration. They, thus, offer almost no protection from injury caused by careless handling (Goddard,1980). The use of plastic films, however, enhances the techniques of controlled atmosphere packaging, controlled atmosphere storage and the absorbent technology (Wills *et al.*,1998).

Modified atmosphere packaging is used in the storage of fresh fruits and vegetables. The term refers to their storage in plastic films which restrict the transmission of respiratory gases. This results in the accumulation of carbon-dioxide and depletion of oxygen around

the produce, which may increase their storage life (Kader *et al.*, 1985), but the composition of the storage atmosphere is not closely controlled (Mitra,1997). Controlled atmosphere storage implies the addition or removal of gases resulting in an atmospheric composition different from that of normal air in which the levels of carbon-dioxide, oxygen, nitrogen and ethylene in the atmosphere may be manipulated. It generally refers to decreased oxygen and increased carbon-dioxide concentrations, and implies precise control of these gases (Wills *et al.*, 1998).

2.6.3.2. TRADITIONAL PACKAGING

Traditional packaging containers like baskets and others for transporting and marketing fresh fruits and vegetables used in the developing countries are mostly constructed from plant materials such as woven leaves, reeds, grass stems, bamboo, cane and palm fronds, guinea corn stalks, rattan, straw etc (Wills *et al.*,1981). They are also designed to be carried, conveyed or transported by man (Kader *et al.*,1985). These package types vary considerably according to geographical location of the area and availability of material for construction (Thompson, 1996). The most common are the bamboo, cane and palm frond baskets which come in multiple capacities and designs i.e. types of weave and shape (FAO, 1989).

Both raw materials and labour costs are normally low, and if the containers are well made they can be re-used (Bonte-Friedheim, 1989). He reported that they are difficult to clean, particularly when contaminated with rot organisms; they lack rigidity and bend out of shape when stacked for long-distance transport; they load badly because of their shape; they cause pressure damage when tightly filled; they are generally not conducive for effective handling or suitable for modern systems of transport, especially as the heavier

loading capacities of trucks result in damage to contents from the rough sides and sharp edges or splints of the split cane or palm fronds. Additionally, even though these baskets may have inner linings of leaves such as banana leaves, where used, are usually not sufficient to prevent damage (FAO, 1981). They are also often too large, contributing to handling problems and making it conducive for heat of respiration to accumulate within (Pantastico, 1975).

One advantage of the traditional basket is that produce are fitted to the package rather than the package to the produce (Wills *et al.*, 1981). The use of packages which have unsuitable dimensions or design and those which are poorly maintained can create a situation where mechanical damage to produce in transit is common (Stokes, 1974).

One of the operations of marketing fresh fruits and vegetables especially fresh tomato in Ghana that create a major problem is packaging, where wooden containers are mainly used for bulk distribution (Kwaa, 1994). Despite these problems, of late, these packages have increasingly gained popularity with Ghanaian market women. This is because wood, as a packaging material, is readily available, its cost is reasonable, it can be worked with easily, and it has a rigid fibrous structure which is almost resistant to ambient climatic conditions (Alomenu, 1992). But the performance of a package, and for that matter a wooden package, depends largely upon the design (Anonymous, 1993).

There has been a shift towards wooden boxes or crates for some high valued very perishable fruits such as tomato and mango in Ghana. The crates are made of tropical hard wood {"*KyenKyen" (Antiaris toxicaria) and "wawa" (Triplochiton scleroxylon)*} which are heavy and inflexible, while the aims of the package design and construction were more of to prevent pilfering than to ensure quality maintenance (Awiti-Kuffour,1997).

Studies by Wills *et al.* (1981) have shown that returnable collapsible wooden crates have been attempted in certain developing countries, but progress has been slow as these packages were found not suitable for safe transportation of fresh fruits and vegetables on relatively poor road surfaces with indifferent handling methods. In view of this, experiments have been made with paper board cartons, but cost factors have tended to rule out their adoption. Nevertheless, some are used for export of pineapples from Ghana to some European countries and of bananas to Japan from the Philippines (GEPC, 1995). Again it has been observed that many types of package are unsuitable for the transport of perishable fruits and vegetables and very little attempt has been made to standardize the design or unit capacity of those packages which are potentially satisfactory (Wills *et al.*,1981).

Alternative designs of containers for produce handling have been published and reviewed by Organization for Economic Co-operation and Development (OECD) and United Nations Industrial Development Organization (UNIDO), but still these designs and modifications made to these local materials being used have not been effectively evaluated in developing countries (FAO, 1981). Even in situations where only a limited range of local materials were available, modifications to design resulted in a saving in produce quality (Rawnsley,1969). An investigation by Rawnsley (1969) in Ghana on modifications to tomato fruit basket design apparently achieved a saving of 12% produce which would otherwise have been lost. The modification was from inverted cone basket to upright cone basket. Similar studies conducted in India by Lakshminarayana *et al.* (1971) on improving existing design packages for mango fruits achieved a fairly remarkable saving of about 15% in produce quality and quantity.

Many items, particularly lower value high bulk fresh fruits and vegetables such as water melon, cabbage and pineapples are transported to internal markets without packages (Thompson,1996). A systematic stacking reduce their potential for damage which is likely to arise as does lining a lorry with prospective material such as grass or leaves and covering the produce during transit so that it will be protected from prevailing weather conditions (Kader *et al.*,1985).

.6.3.3. HARVESTING OR FIELD CONTAINERS

Picking or harvesting containers are of many types depending on the crop, the region, and availability of materials. Picking bags made of canvas, burlap or mesh, hampers and baskets of woven veneer or bamboo are used widely (Ryall and Lipton, 1972). According to the authors, metal pails with canvas bottoms for unloading are sometimes used for fruits and vegetables such as tomato fruits and that the field containers are unloaded into larger field boxes or pallet bins. Stout *et al.* (1968) stated that citrus, carrots and mature-green tomato fruits are often transferred from picking containers into pallet bins or bulk boxes. Kushman (1967) also stated that ripe tomato fruits and sweet potato may be left in the hamper or basket into which they were picked, and that sometimes produce is tossed directly on to trailers or trucks.

Experience in Central California indicates less physical damage to tomato fruits hauled in bins holding 152-304 kg, than in the conventional field boxes, and that mature green fruits loaded 304 kg to the bin graded only 57% number one (1) at packaging as compared with 82% number one (1) for those loaded only 152 kg to the bin (Ryall and Lipton, 1972).

Tests with materials for pallet bin construction showed little difference in fruit damage between wire-mesh, plastic, fibreboard and wood, but the important factors were rigidity, life expectancy, and ease of cleaning. However, the depth of fruit in the pallet bin did affect the amount of damage after extended truck transport (Stout *et al.*, 1968). Harvesting produce into cartons, wooden boxes or metal cans which have been used for other commodities is common practice of small scale farmers in many developing countries. For example the Sudan imports a lot of tomato paste in 10kg cans. After the pulp has been used they are used by the local farmers for harvesting fresh tomato fruits, and have become the standard measure on local markets (Thompson, 1996). The situation is not different in Ghana – in addition to this, calabashes, rugs, small baskets made from cane or palm fronds as well as from guinea corn stalks, small plastics, metal and aluminium containers or pails etc. are also used for harvesting tomato fruits (personal observation).

2.6.3.4. SHIPPING CONTAINERS

Packing for shipping and handling requires engineered containers to protect produce from bruising, vibration and the weight of other stacked containers. The ideal pack consists of a tight-fill without a bulge in a hidden container having sufficient stacking strength to protect the contents under all handling conditions (Wills *et al.*, 1998). Any shipping container should be designed to meet the specific requirements of the particular fruit or vegetable (Pantastico, 1975).

Pantastico (1975) stated that in more developed countries, many shipping containers are used only once and are not returned to the shipper, but in less developed countries, containers are often returned or sold and receive multiple use. The author added that

shipping containers should be labeled with large print to specify the commodity, variety, weight or count, grade and source.

Chapogas and Anthony (1971) indicated earlier that wooden containers can be the strongest and most rigid type of shipping containers but strength depends on the thickness of materials used, and that common types include nailed wooden boxes and crates, wire-bound boxes and crates, plywood boxes, bulk bins or pallet boxes and wooden pallets.

According to Wills *et al.*(1981) there is little value in naming specific containers for different fruits and vegetables since several types may be satisfactory, depending on the region, the distance to market, method of pre-cooling, the quantity or weight shipped and the availability and cost of materials. However, a substantial quantity of tomato fruits, melons, celery and other commodities continue to go to market in nailed wood boxes but the trend for many products has been towards fibreboard, veneer and plastics as shipping container materials (Ryall and Lipton, 1972)

Schuur (1988) also stated that fibreboard cartons are as well common for mature green tomato fruits and avocado, and as master containers for consumer-packaged vegetables such as cellophane-wrapped cauliflower, trays of tomato fruits and polyethylene bags of carrots or other root crops. Pantastico (1975) reported that fruits and vegetables for processing such as tomato, carrots, sweet potatoes, citrus and pineapples are often shipped in bulk bins.

According to Ryall and Lipton (1972), shipments from the major tomato producing districts in the USA are mostly jumble-packed in 27 kg wire bound crates and 18 kg

fibreboard cartons or Los Angeles lug boxes. They added that there is an increased use of the 18 kg carton for mature-green tomato fruits because of the dual purpose role it plays as a shipping container and as a container for the repacker to use in distributing consumer packs to the retail store. Hot-house tomato fruits are largely packed in wood or fibreboard flats or in veneer or fibreboard baskets (Ryall and Lipton ,1972).

Gould (1983) reported that in Columbus, Ohio State, tomato fruits are transported from the field to the processing plant in either hampers, lug boxes, plastic boxes or bulk containers, and that the hamper had a capacity of 16 kg of tomato fruit; the lug box varied in capacity from 18-23 kg of tomato fruits, with standard inside measurements of 20cm deep, 36cm wide and 53cm long and a 2cm cleat on the top edge to reduce damage to the fruit when the boxes are stacked; the plastic box container holds 18-23 kg of tomato fruits and advantageously about half the weight of the standard lug box and can as well be nested. Bulk boxes hold from ¼ to more than a ton of tomato fruit with dimensions as 114cm long, 109cm wide and 20cm, 30cm or 41cm deep, holding 145 kg, 221 kg and 288 kg of tomato fruits respectively. Rawnsley (1969) and Kwaa (1994) both indicated that shipment of tomato fruits in Ghana is to a lesser extent by the basket and to a larger extent by the wooden crate.

3.5. CONSUMER PACKAGING

Packaging in "consumer-size" units before final sale in the retail store is not of recent origin, as indicated by or evidenced by the millions of cans and bottles of preserved foods that have been used for generations. Even the packaging of fresh produce is not new, for most fresh fruits and vegetables have always been packaged in some fashion before the customer carried them home. However, prepackaging of fresh produce, which infers a consumer size package prepared prior to final sale, dates back only to the mid 1940's in U.S.A. (Ryall and Lipton, 1972).

Pantastico (1975) showed that use of small consumer-sized packages for produce has grown with the increase in large self-service markets for retailing and that in simple form it may consist only of having a supply of paper or plastic bags available for customers to select, package and weigh their purchases. Standard-sized units are packed after washing and grading; for example, four tomato fruits in a film over wrapped tray, 12 oranges in a polyethylene bag, 0.45 kg of grapes in a film bag or 1.8 kg of sweet potatoes in a mesh bag where each unit is labelled as to commodity weight or count, brand, source and other information, and then packed in master shipping containers usually made of fibreboard (Pantastico, 1975).

Schuur (1988) stated that consumer packages include bags made of paper, film, cotton or plastic mesh; trays of molded pulp, paper board, plastic or foamed plastic; folding paper board cartons, sometimes with a clear plastic window or with dividers for individual fruits. Further, small rectangular or round baskets, punnets, or cups of molded pulp, plastic veneer or coated or waxed paper board are also used. He also indicated that pre-

packaging or retail packaging of certain commodities in specially designed consumer packages has the following advantages: deterioration of the produce is slowed down as spoilage caused by consumers selecting out of a bulk produce is reduced; time needed for weighing and checking after selecting by the consumer will be reduced; advertisement by abundant supply; and more protection to the produce.

Wills *et al.* (1998) stated that produce purchased at retail outlets was traditionally packaged in paper bags but have been largely replaced by polyethylene film bags which are cheaper, stronger and usually transparent because consumers are sometimes wary of the quality of packaged items, and may still opt to select individual produce items from an open display. However, the authors cautioned that such packaging can also provide a modified atmosphere benefit whose effect is somewhat risky and generally not sought, and that such films should be perforated to prevent significant modification of the package atmosphere.

Earlier studies conducted by Hardenberg (1954) showed that two 0.64cm holes in a sealed film bag holding four ripe tomato fruits permitted maintenance of essentially normal atmospheres in these high respiratory products at 21.1°C. Ryall and Lipton (1978) reported that partially ripe tomato fruits or peaches in non-ventilated film may never ripen satisfactorily because of the accumulated carbon dioxide and that they may also develop a fermented or winery taste.

Films vary in their permeability to water vapour. For example, cellulose acetate, sometimes used for over wrapping tomato fruits, is quite permeable, allowing considerable loss in weight but with about 50% moisture retention over non-wrapped produce (Risse, 1989). He added that polyethylene and polyvinyl-chloride on the other

hand are more moisture proof; little weight is lost and enclosed produce remains crisp. Perforations that are adequate for carbon dioxide and oxygen diffusion such as four 0.32cm holes in a polythene bag are very small compared with the total film surface and they do not significantly increase moisture loss.

Pantastico (1975) stated that few data show that consumer packaging of fresh produce has any marked effect on nutritional substances and that refrigeration conserves nutritional substances in produce much more effectively than film packaging. Henig (1975) stated that usually sugars and vitamins are not retained any better in produce packaged in film than in non-wrapped produce, although retardation of wilting will reduce losses of vitamin C and carotene.

Rawnsley (1969) and Kwaa (1994) again have both indicated that available consumer packages present in the Ghanaian market for tomato fruits include small woven baskets, low density polyethylene film bags, paper bags, empty emulsion paint containers, aluminlum pans, flat oval boards and small plastic buckets. Others are stuffed old-kitchen bowls and tin containers (personal observation).

PACKAGE STANDARDIZATION

Boyette *et al.* (1996) stated that produce package standardization is interpreted differently by different groups, and that the wide variety of package sizes and material combinations is a result of the market responding to demands from many different segments of the produce industry.

Schuur (1988) earlier on stated that a number of non-standard sizes of package are in use all over the world but that the International Standards Organization gives a series of dimensions for rigid rectangular packages based on a standard plan dimension or module of 600 x 400mm as the external size of a package unit when fully loaded (including bulge). The OECD standards have pallet size 1200mm x 1000mm as a standard unit which is less comprehensive than the ISO standard.

According to the author, all standards leave the height of the crate to the discretion of the user and that the height is generally influenced by the commodity, type of crate, required weight or count, stacking method, etc. Using standard heights would simplify the transport of crates (Stokes, 1974).

Chapogas and Anthony (1971) reiterated that marketing costs can be reduced by the use of standardized package sizes, and that if containers could be standardized, inventory investment in packaging materials could be reduced and mass production of containers would be facilitated. In another development Stokes (1974) also stated that with the advent of mechanical handling of groups of package, standardization of container types has been under way for some time and is needed to reduce number of types and sizes which make the best use of available space and stack well.

Wills *et al.* (1998) stated that in modern packaging, dimensions are both economically and structurally of great importance. These standard dimensions facilitate economic use of materials, offer adequate strength and allow easy and secure handling, loading and stacking. According to the authors the optimal length to width ratio is about 1.5:1. UNDP/FAO/MOFA (1988) reported that bruises and squashing occur when tomato fruits

are packed in layers more than five, i.e., a height above 180 mm. Tweneboah (2000) indicated that the first consideration in the design of a packaging container is how many layers of the produce can be put on top of each other without running the risk of crushing the bottom layers and that for ripe tomato fruits the maximum appears to be 3 to 4 layers. Thirty litre (about 20kg of produce) and 15 litre packages are becoming standard for fruit, with larger 36 litre packages being used for some vegetables (Wills *et al.*; 1998).

6.3.7 EFFECT OF PACKAGING ON POST-HARVEST LOSSES OF TOMATO FRUITS

Total world fresh produce exports in 1986 were estimated at US $ 226,505 million (Schuur, 1988). A loss of one percent equals a financial loss of US $ 2265.05 million. He added that only a small part of the world production of Agricultural produce is exported and that by FAO (1981) estimates, post-harvest losses were in the order of 20-33% of all food produced.

Post-harvest losses are losses occurring in the period between harvesting and consumption. The term "loss" in the context of this thesis is used in a wider sense including all types of losses for the farmer, trader and consumer e.g. weight loss, quality loss, financial loss, loss of good will, loss of marketing opportunities, loss of nutritional value etc following that expressed by the FAO (1981). A small reduction in post-harvest losses will therefore result in lower financial costs and in an increased availability of food (Schuur, 1988). According to him other financial losses such as loss of market opportunities, loss of quality, loss of good will, etc can also result in a financial loss for the trader or farmer. One, and perhaps the most important means of reducing these losses

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is the introduction of improved packaging materials together with improved packaging techniques (Villareal, 1980).

The distribution system of fresh tomato fruit in Ghana is complex and the movement of the produce from the farmer to the consumer consists of many handling steps (Kwaa, 1994), uses low technology and is in the hands of many small traders (Rawnsley, 1969). These factors amongst others, combined with the high perishability of the produce, are contributing to high spoilage and necessary loss of produce (Rawnsley, 1969).

.3.7.1 Physical/Mechanical Damage Considerations

Packaged fruit and vegetables vary widely in their susceptibility to mechanical damage and in the types of mechanical injury to which they are susceptible (Boyette *et al.*, 1996). For packaged fresh tomato fruits, two types and various causes of mechanical injury to produce can be identified. They are open wounds and bruises (Table 4).

Table 4: Mechanical damage suffered by packaged fresh tomato fruits.

Injury type	Cause	Effect
Open wounds (skin ruptured, cells damaged)	- Breakages and cuts through careless handling. - Punctures through injuries from hard (pointed/angled) objects piercing package/produce e.g splinters in wooden containers, staples, nails and protruding stems in calyx etc. - Scuffs through abrasion against a rough surface.	- Increases the rate of water loss. - Increases susceptibility of produce to microbial decay and subsequent rapid rotting. - Increases rate of respiration (heat production). - Evokes ethylene evolution as part of wound response. - Results in fruit dis-colourations (external and internal) by decompartmentalising cellular components and exposing them to oxygen. - Results in loss of aesthetic value from excessive respiration and transpiration.
Bruises (skin not ruptured, cells damaged)	Impact bruises through impact against a hard (flat)surface e.g. throwing/dropping of packages, sudden start/stop of vehicles etc. -Compression bruises through excessive pressure e.g. in over sized containers, containers over filled or stacked too high or both,collapse of stack containers durintransport, weak packaginetc. -Vibration bruises through repeated and prolonged vibration of fruit against an adjacent surface e.g. .vibration of the vehicle itself through poor fuel transmission and from rough road and bad shock absorbers.	

Sources: Bonte-Friedheim (1989)

Olympio (2002, personal communication)

Author's Personal observation

According to Mitra (1997) inappropriate packaging may cause mechanical damage of the produce due to bruising or abrasion as the commodity moves about during transport. In other words individual items should not be allowed to move with respect to each other or to the walls of the package in order to avoid vibration injury; and the package should be full without packaging too tightly, which increases compression and impact bruising. Thus both under-filling and over-filling are to be avoided so that individual items are held firmly, but not too tightly within the package. The relative susceptibilities of fresh tomato fruits to compression, impact and vibration injuries were also shown by Guillen (1964). The author indicated that tomato at mature green is less susceptible to impact and vibration than compression, while pink or ripe fruits are only less susceptible to vibration.

Wills *et al.*(1981) stated that tissue deformation and browning via mechanical damage is exacerbated by increased water loss as a result of damage to the cuticle, and also represent sites for microbial infection in terms of both damage to the protective skin and release of substrates (e.g. sugar) for growth. They added that the inclusion of dirt from the field can aggravate the situation. The physiological wound response involves increased ethylene production and respiration, and hence acceleration in the rate of produce deterioration with consequent loss of edible material because of the need to trim off unsightly portions or to discard whole fruits (Wills *et al.*, 1998).

Tindall (1983) earlier on indicated that produce can overheat and rapidly deteriorate during temporary field storage, and that failure to sort and discard immature, over-ripe, under-sized, misshapen, blemished or otherwise damaged produce, creates problems in the subsequent marketing of fresh tomato produce.

Gould (1983) reported that different sizes of bulk boxes for handling tomato fruits indicated that as the depth of the box increased, fruit injury expressed as cracked fruit also increased. There was also a great amount of injury when the machine dumped the fruit than when it was dumped by hand from lugs into bulk boxes (Table 5).

Table 5: Mechanical injury occurring due to harvest methods into three depths of boxes.

Depth of bulk box (cm)	Harvest method		
	Hand (% injury)	Machine (% injury)	Average
20	11.1	22.1	16.6
30	12.8	30.2	21.5
41	13.0	33.0	23.0
Average	12.3	28.4	

Injury expressed as percentage of fruit cracks over 2.54cm long.
After Gould (1983).

Bonte-Friedheim (1989) indicated that exposure of packages to external heat e.g. direct sunlight or storage near heating systems, and natural build up of internal heat of produce owing to poor ventilation within package in storage or vehicle can have major deleterious effects like over ripening, softness, wilts and off-flavours, decays etc. He also indicated that exposure of stacked cardboard containers to rain or high relative humidity and condensation results in their softening and collapse with subsequent squashing of produce. Pierce (1987) observed that exposure of untreated (with an ultraviolet inhibitor) plastic sacks and crates to direct sunlight causes disintegration of the plastic material which cut or bruise the produce when it is moved.

Work done on post-harvest losses of some fruits and vegetables (Ryall and Pentzer, 1982) indicated that out of total post harvest losses (14.1%) of packaged tomato fruits, losses due to mechanical injury were about 2.5%.

2. Physiological Considerations

Post-harvest physiological disorders are mostly injuries due to temperature and controlled atmospheres, mainly carbon-dioxide and oxygen levels - the others include relative humidity and ethylene effects (Lieberman,1983).

Schuur (1988) stated that proper packaging is required to allow ventilation and heat exchange in order to maintain proper temperature level to reduce the air and gas exchange and minimise water loss. He recommended that holes in cartons should be at least 5% of the total box surface to allow for ventilation. Tindall (1983) had earlier stated that with mixed storage or mixed load of different commodities, ethylene produced from ripening fruit can promote rapid senescence in the fresh tomato fruit. When fresh tomato fruits are exposed to ethylene emission sources like internal air combustion engines, pollinated flowers, decaying products, ripening rooms, cigarette smoke, rubber materials exposed to heat or ultraviolet light and virus infected material, rapid senescence in the fresh tomato fruit can also be promoted (Swiader *et al.*, 1992).

According to Grierson and Kader (1986) temperatures above the freezing point but below 12.8 °C cause chilling injury. They also reported that temperatures above 30 °C are equally injurious, and that fruits in a package exposed to such temperatures ripen irregularly or fail to ripen, become soft prematurely, have surface pitting, browning of seeds, increased rot, unpleasant flavour due to increase acidity and loss of characteristic aroma. Bleasdale and Salter (1991) stated that the rate of transpiration must be minimized to avoid loss in saleable

weight, wilting and shriveling of the fresh tomato fruit by exercising good handling conditions including packaging at recommended humidity and temperatures. This is because only 5% weight loss is enough to make vegetables become limp and unattractive and also more likely to be attacked by fungi and bacteria.

Bonte-Friedheim (1989) associated the causes of overheating in fresh produce to include the use of closed vehicles without ventilation; close-stow stacking patterns blocking the movement of air between and through packages, thus hindering the dispersal of heat. He stated that the lack of adequate ventilation of the packages themselves; and exposure of the packages to the sun while awaiting transport or while trucks are queuing to unload at their destinations also lead to overheating.

In work done on post-harvest losses of some fruits and vegetables, it has been shown that out of total post-harvest losses (14.1%) of packaged tomato fruit, losses due to physiological injury or non-parasitic disorders was about 0.9% (Ryall and Pentzer, 1982).

.7.3. Pathological Considerations

According to Tindall (1983) many of the mechanical and physiological hazards of packaging inflicted on fresh produce are aggravated by pathological breakdown resulting from rotting fungi and bacteria. High humidity conditions are conducive to microbial growth, especially in produce damaged during harvesting and handling. Hultin and Milner (1978) also observed that biological and microbiological losses refer to the consumption of or damage to produce by insects, birds, rodents, bacteria, rotting fungi etc. Adequate packaging, stacking and storing can reduce the incidence of this type of losses. Pierce (1987) observed that infection after harvest can occur at a time between the field and final consumption and that, it is for the most part, the result of invasion of harvesting or handling injuries by moulds and

bacteria. He stated that post-harvest diseases can be spread by field boxes contaminated by soil or rotting produce or both, contaminated water used to wash produce before packaging, and rotting rejected produce left lying around packing houses.

Lieberman (1983) earlier on stated that over 20 different fungi species had been associated with post-harvest rot in fresh tomato fruits. It has also been found in work done on post-harvest losses of some fruits and vegetables (Ryall and Pentzer,1982) that out of total losses (14.1%) of packaged tomato fruits, losses due to pathological injury or parasitic diseases were about 10.7%. Meanwhile Grierson and Wardowski (1978) stated that the major hazard responsible for the end of effective storage and marketing life of the tomato fruit, sweet potato, berries and citrus is rot.

7.4. Bio-Chemical Considerations

Under the best post-harvest handling practices, tomato fruits are first washed, waxed, and then graded before being carefully packaged in containers (Villareal, 1980). She indicated that some chemical and bio-chemical losses that may be incurred via packaging are as follows: contamination of containers stored near chemicals; damage to produce by containers treated with preservatives e.g. boxes made from wood treated with pentachlorphenate (PCP); contamination of produce from boxes affected by mould growth can result in flavour contamination or surface damage and discolouration of produce in contact with such containers; rotting of produce owing to contaminating moulds; and wood decaying moulds causing collapse of boxes.

8.1. EFFECTS OF GHANAIAN PACKAGING CONTAINERS AND TECHNIQUES ON TOMATO FRUIT QUALITY

Most fruit and vegetable farming, e.g., tomato farming is done mostly by peasant small scale farmers who have little knowledge on the importance of cool storage of fresh produce immediately after harvest (Rawnsley, 1969). Even if they have the knowledge, the facilities are simply non-existent (Kwaa, 1994). Kwaa (1994) added that almost all tomato fruit retailers are ignorant of the importance regarding nutrient retention in cooling fresh produce. He also indicated that in Ghana most fruits and vegetables, e.g., tomato fruits are packaged directly in the harvesting field and distributed to consumers without any prior pre-treatment.

According to Lyon *et al.*(1996) some tomato fruits are cultivated near big drains where there is easy access to dirty water. After harvest, these products are not pre-treated before packaging and deterioration sets in easily because of the high microbial loads associated with the dirty water. Sometimes too, these harvested products are conveyed for sale in large and deep baskets and crates as well as in metal and aluminium containers. Such high microbial loads coupled with the heat generated within the enormous package whilst on transit and in storage enhance spoilage.

The raffia palm and cane woven baskets as well as the existing rough splinters of wooden crates though contain and protect produce from spillage (to some extent), do little in protecting produce from microbial contamination, excessive heat, moisture loss and bruises. These lead to loss of ascorbic acid, excessive shrivelling and wilting and subsequent reduction in shelf-life of the fresh tomato produce (Bonte-Friedheim, 1989).

With rigid and strong cell walls, a firm texture is maintained. Packaging of produce in such splinters of baskets and crates for distribution and retail lead finally to loss in texture (Pantastico, 1975). In Ghana there is over-ripening of tomato fruits even before they get to the consumer because tomato fruits are traditionally harvested red ripe (Lyon *et al.*, 1996). This situation is aggravated by the high tropical ambient temperatures where metabolic reactions are normally temperature dependent (Matoo *et al.*, 1975)

6.3.9. MAGNITUDE OF MARKET LOSSES OF PACKAGED TOMATO FRUITS

Although this topic has been the subject of very considerable debate over the years, remarkably little reliable information is available on the magnitude of post-harvest losses of packaged tomato fruits.

In Ghana, when tomato fruits were packed and shipped to urban centres in conventional "inverted cone" baskets, transportation losses was around 15%. When "upright cone" baskets i.e. flat-bottomed with sides converging towards the top were used and the tomato fruits packed on a thin layer of dried grass, losses in the same handling chain were reduced to about 3% (Rawnsley,1969).

According to Harvey (1978) post-harvest losses in selected fruits and vegetables sampled at wholesale, retail and consumer markets in the New York market area gave the following results for packaged tomato fruits; out of a total loss of 14.2%, losses at wholesale level were zero, retail level were 6.3% and consumer level were 7.9%. Work done by Ryall and Pentzer (1982) on wastage in various types of horticultural produce during wholesaling in Developing Nations revealed 30% wastage for tomato fruits.

Devkota and Ghale (1992) looked at percent (%) losses of selected vegetables during marketing in Nepal and found that out of a total loss of 17.85% for tomato fruits, wholesale losses were 12.07% and retail losses were 5.78%. Losses between the farm and the wholesale market in Thailand were investigated by Amuttiratana and Passornsiri (1992) and it was revealed that percentage weight loss and losses due to defects suffered by fresh tomato fruits were 3.33% and 6.89% respectively. The authors also reported losses between the wholesale and retail markets in Thailand and it was found that weight losses, losses due to bruises, rot and trimming were in the order of 0.41%, 9.03%, 0.05% and zero percent respectively out of a total of 9.49% of fresh tomato fruits lost.

2.6.4. PACKAGE DESIGN

Packaging usually represent about 2% of any country's gross national product and the figure for world-wide expenditure for packaging production and services is between US $ 400 and 500 billion annually with an estimated 16% of the price of the product represented by packaging in the food sector . Packaging material in developing countries frequently costs 50-100% more than the equivalent materials in the industrial countries, which means that the share of packaging costs for fruits and vegetables may be as high as 50% of the free-on-board export price. Thompson (1996) found that about 14% of the cost of a basket of goods from a supermarket was for packaging.

Buel (1986) stated that size of the package is important and should be designed in terms of the amount the market or customer requires in a single unit. He added that the package size might be dictated by what a person can reasonably lift or carry. Thus, the package should be as simple and as inexpensive as possible, whilst remaining consistent with the primary objectives of protection and attractiveness at the point of sale (Villareal, 1980).

Protection of the produce is influenced by the length of journey, the environmental conditions, the type of handling and any hazards it may be exposed to (Wills *et al.*,1981). Thus the package design is important for it to function properly. The package must, therefore, have adequate strength without being too heavy or bulky, and must also allow adequate ventilation (Wills *ėt al.*, 1998). The use of standard pallets is increasing and the package may have to be designed to fit these or to fit a standard refrigerated container (Thompson, 1996). Designing to foster better package presentation is thus also a necessity. Thompson (1996) also indicated that there are often legal requirements for consumer and wholesale packs, where information on the origin, type, quality, grade and weights or counts of the product needs to be displayed on the outside of the package, thereby aiding management and marketing.

Field containers must be well designed. In many cases, the produce is packed into the containers in the field, and it stays in the same container right through to the wholesale or even to the retail market (Ryall and Lipton, 1972). The advantages of this are that the produce is only handled once, so that potential for mechanical injury is reduced. Also, handling takes time and labour, both of which can be expensive. The construction, operation and maintenance of a pack house can likewise be expensive and direct field packing can eliminate the necessity for having a pack house.

Packaging can influence temperature management and water loss (Mitra, 1997). To reduce water loss, plastic wraps and liners may be used, but the restriction of ventilation so caused can result in problems of low oxygen and high carbon dioxide or accumulation of water. The packaging itself can absorb moisture, thereby drying out the produce; this

can be limited through the use of wax or plastic-coated packaging material which are also water resistant.

The cost and cost-effectiveness of the package and whether it is easy to assemble, fill and close are primary considerations (Boyette *et al*., 1996). No matter how well the package is designed and filled, if it is handled roughly, thrown and dropped, there is again a risk that the produce will be damaged (Wills *et al*., 1998).

6.4.1. EFFECT OF DESIGN ON PRODUCE QUALITY

The function of a package is primarily to contain and protect the produce against a variety of hazards which might adversely affect its quality during handling, distribution and storage (Brennan *et al*., 1990). Buel (1986) earlier on stated that the size of the package is so important that it should be designed in terms of the amount the market or customer requires in a single unit and that in other circumstances the package design may be dictated by what a person can reasonably lift or carry in order to maintain produce quality.

Fruits and vegetables, being living organisms, give out heat and gases which can be detrimental if allowed to accumulate in the package, so it may need to be ventilated (Wills *et al*., 1998).

Thompson (1996) stated that certain types of packaging can be used to extend the storage life and quality of crops, such as plastic films to modify the atmosphere or to protect the crop from infection or infestations.

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According to Paine and Paine (1983), it will be noted that in the construction of designs of storage containers, a range of sizes, shapes and materials are utilized. Brennan (1977) earlier on stated that before considering these various types, major factors affecting the choice of materials and design must be mentioned. These factors include mechanical damage, temperature changes, permeability characteristics, chemical and biochemical considerations as well as microbiological and biological considerations. For example,Thompson (1996) found out that the shape of baskets which are usually circular or at least have rounded corners, gives less storage for a given space than other types of containers. He added that baskets provide very good ventilation for produce, but because the materials from which they are made are rough they can often damage the produce, by abrasion during handling and transportation. Cushioning materials such as paper or leaves is often used to line baskets to reduce abrasion, but this also reduces ventilation.

As reported by Thompson (1996), non-standard sizes can make packages difficult to stack in lorries or stores and, that often unplanned inner surfaces or protruding nails can damage produce. He indicated that many wooden crates are made by hand which result in slight variations in size and shape. Wood can take up moisture or, if not properly cured, it can lose moisture. Both these events can cause the wood to warp, which again can make stacks of boxes unstable.

Bonte-Friedheim (1989) stated that round baskets, whether cylindrical or tapered, hold considerably less produce than do crates occupying the same space and that a cylindrical basket contains only 78.5% by volume compared with a rectangular box occupying the same space. A study in Thailand showed that a plastic crate, while costing five times as much as traditional bamboo basket of similar capacity, was still useful after 20 times the

number of journeys, putting the cost per journey of the plastic crate of about one-quarter of that of the bamboo basket. The plastic crate also provided better protection for produce, easier handling and better storing, and was easier to clean. Perhaps improvements in the design and construction of wooden crates might in the context of the small-scale trader, prove to be a better solution than buying plastic crates.

3.0 MATERIALS AND METHODS

Three experiments were conducted to evaluate the existing packaging methods used for marketing of tomato fruits in selected growing /marketing areas of Ashanti and Upper East Regions and the development of improved packaging techniques. They included a survey, laboratory analysis and designing and developing an improved packaging unit (Figure 1).

The survey was carried out in some major tomato growing/marketing areas within Ashanti and Upper East regions to find out the types of packaging materials used in Ghana. This was accomplished through administering questionnaire to the three sectors of the tomato industry (producers, wholesalers and retailers). Based on the survey findings the wooden crate, discovered to be the common packaging unit for bulk distribution of tomato fruits, was evaluated. Thus, physical and chemical tests were carried out in the laboratory to evaluate the post-harvest losses and quality changes in the packaged fresh tomato fruits after subsequent commercial handling and transportation. Then the empty crate weight, volume and other dimensions of the different container types (Small and Big) were recorded for statiscal analysis. This was followed by the development of an improved wooden crate.

3.1. EXPERIMENT 1: SURVEY

For the survey, some major tomato growing/marketing areas within Ashanti and Upper East regions were selected. In all three hundred and seventy stakeholders were interviewed.

3.1.1 QUESTIONNAIRE DESIGN

Different questionnaires were designed for the three sectors of the tomato industry; the growers, distributors (middlemen) and retailers. In general, parameters considered in the design included; in addition to biodata and background of farmers and traders, production and post-harvest practices of farmers at the farm-gate and, the marketing and socio-economic status of traders at selected marketing centres following the recommendations of Casley and Lury (1981).

3.1.2 SAMPLING AREA

The study was carried out using selected major tomato growing centres in Ashanti (Akumadan and Agogo) and Upper East (Tono and Vea) regions where farmers were assessed. Selected major markets in the regional capitals for retailers were also used. In Ashanti region, retailers at four locations in the Kumasi Central market (Roman Hill, Bola, Race course) and Asafo market were assessed. In the Upper East region the Bolgatanga old market and new market centres were areas where retailers were assessed. Distributors were assessed at the various farm-gates (Akumadan, Agogo, Tono and Vea) and at the retail end.

3.1.3 QUESTIONNAIRE ADMINISTRATION

The designed questionnaire was first pre-tested in the Offinso District at Akumadan for farmers and, at Race course for retailers. Pre-testing for wholesalers was done at both Akumadan and Race course. Data obtained were analysed statiscally and based on the results, modifications were made to the questionnaire. The modified questionnaire was then administered to the growers, distributors and retailers in the selected areas. Respondents were picked at random. About one hundred respondents – thirty-three each of farmers, wholesalers and retailers were interviewed for pre-testing. For the actual survey, three hundred and seventy respondents were interviewed. These comprised of one hundred and thirty-two farmers, one hundred and five wholesalers and one hundred and thirty-three retailers.

3.2 EXPERIMENT 2: EXISTING WOODEN CRATE EVALUATION

The wooden crate (small or big sizes) which is commonly used for bulk distribution of fresh tomato fruits as revealed in the survey was generally assessed. Here, physical and chemical analyses of fruits in these containers were carried out. Other parameters considered in the assessment of the packaging unit were empty crate weight, empty crate volume and the various dimensions of the container. The weight, volume and the various dimensions were compared to standards recommended by the International Labour Organization as stated by Wills *et al.*(1998).

3.2.1. EXPERIMENTAL DESIGN AND ANALYSIS

A two factor Completely Randomised Design (CRD) was used. The two factors were location/source and crate-type. All determinations were in triplicate. Data obtained from the

experiments were statistically analysed using computer MSTAT programme. Differences between treatment means were separated using Duncan's Multiple Range Test.

3.2.2. PHYSICAL AND CHEMICAL ANALYSIS OF FRUITS

The physical and chemical analyses of fruits under the existing wooden crate evaluation were done as follows.

3.2.2.1. SOURCE OF RAW MATERIAL

Red-ripe tomato fruits of Laurano cultivar, obtained from Akumadan and Agogo in the Ashanti region and, Tono and Vea in the Upper East Region were used for the experiment.

3.2.2.2. SAMPLING METHOD

Three wooden crates of tomato fruits each of the smaller Kumasi crate and the Bigger Accra crate were randomly marked from a large number of packages awaiting stacking at the farm-gates of Akumadan and Agogo in the Ashanti region and, Tono and Vea in the Upper East region. These among others were transported by means of a seven ton Ford "*Kia*" vehicle to Kumasi central wholesale market at Roman Hill. "*Kia*" is the most common vehicle employed in transporting fresh tomato fruits from the farm-gate in Ghana. It has a low body, varied capacity and an open back. At the wholesale market, the samples were held overnight in their original containers in order to simulate the average period that the commodity usually stays before being sold. After this holding time the samples were also transported to the laboratory, KNUST, for both physical and chemical analyses. In all, twelve of the smaller size and twelve of the bigger size crates of tomato fruits were sampled.

3.2.2.3. PHYSICAL ANALYSIS OF FRUITS

Parameters considered for physical analysis were determination of damage factors, shelf-life, firmness and mean fruit weight.

.3.1. Determination of Damaged Factors

Tomato fruits in each treatment were sorted into slightly damaged, not damaged, i.e., sound fruits and completely squashed. Then the slightly damaged were sorted into three groups, comprising:

- Slightly physiologically damaged (wrinkling, shrinkage and over/too softened fruits due to wilting and over ripening)
- Slightly pathologically damaged (sunken spots, rotten and mycelia growth on fruits due to bacterial and fungal rot) and
- Slightly mechanically damaged (cuts, punctures, scuffs and abrasions on fruits due to open wounds and, bruises due to impacts, compressions and vibrations).
- Sound fruits were those free from any damages.
- Completely squashed fruits were those damaged to the extent that they could not be identified in singles.

Each group was weighed using 'shen chan'weighing scale and their percentages in the bulk sample determined.

.3.2. Shelf-Life Determination

Twenty sound fruits were randomly picked from each treatment and put into open plastic containers on a laboratory bench at room temperature (25-28°C). Fruits were examined and rotated daily and those found to be damaged after each day's examination were discarded. The number of days each fruit took to show any sign of damage was recorded

as the shelf-life and the affected fruit (s) discarded from the lot up to the last fruit. The mean number of days was determined and recorded as shelf-life of the fruits in the particular treatment.

2.2.3.3 Firmness Determination

This parameter was determined using a simple tomato scoring device constructed for the purpose (Adomako, 1999). Ten of the sound fruits were randomly picked from each treatment for the determination of this parameter. A known weight of 500g held in place by a string attached to a lever was allowed to fall through a PVC tube (diameter 4cm), held in place by a retort stand from a height of 60cm to hit the fruit placed below the tube any time the lever is released. The force exerted on the fruit was calculated using the equation:

Force = mgh

Where m = mass

g = acceleration due to gravity.

h = height through which the mass falls,

From the experiment, m = 500g, g = 9.8m/s and h= 60cm.

Therefore:

Force = mgh

= 0.5kg x 9.8m/s x 0.6m

= 2.94 Newtons (N).

The extent of damage caused by this force (2.94 N) on the fruits was scored on the scale 1-5.

1 = No dent

2 = Dented but no crack.

3 = Fruit cracked but no juice out.

4 = Fruit split, juice spilt but no seeds out.

5 = Fruit crushed, seeds out.

Values were recorded for each fruit and averaged for each treatment.

NB: Those with least score values were firmer than those with higher score values according to the scoring scale.

2.2.3.4. Mean Fruit Weight Determination

This was determined by dividing the total weight of sound fruits in each treatment by the total number of the sound fruits counted in the same treatment. Values were recorded in grams for each treatment.

.2.4. CHEMICAL ANALYSIS OF FRUITS

A sample was taken from each group in each treatment for the analysis. Parameters for analysis were pH, titratable acidity, total soluble solids, reducing sugars and ascorbic acid content.

2.2.4.1 Total Soluble Solids and Reducing Sugars

The juice from the randomly picked fruits from each group was pressed out. A drop or two of the juice was placed in the prism or sample chamber of Bausch and Lomb Abbe hand refractometer (Model Carl Zeiss 9,077, Germany). Values were read and recorded in percent total soluble solids and percent reducing sugars directly from the scale superimposed over the refractive index.

2.4.2 pH Determination

Each sample taken from each group in each treatment was homogenized using a Binatone blender (Model BLG-23, Hongkong). The pulp was then filtered through a dry filter paper (Whatman No. 1, 12.5cm) and the pH of the filtrate determined using Mettler Toledo pH meter (Model 320, New York) standardized at pH 4, 7 and 10 with BDH standard buffers.

.4.3. Titratable Acidity Determination

Titratable acidity (% total acid) was analysed by the AOAC (1984) method. Twenty milliliters of the filtrate in each group was titrated to pH 8.1 with 0.1N NaOH solution using two drops of 1% phenolphthalein as indicator. The average weight of NaOH in duplicate titrations required for an end point of pH 8.1 was multiplied by a factor of 0.064 and expressed as percent citric acid after Ruck (1963) using the formula:

$$\% \text{ Total acid} = \frac{\text{titre x normality of alkali x vol. made up x equiv.wt of acid x 100}}{\text{vol. of sample taken for estimation x wt. or vol. of the sample taken x 1000}}$$

.4.4. Ascorbic Acid Determination

Total ascorbic acid was determined by methods described by Ball (1994). They are the Titrimetric methods for vitamin C; titration with 2, 6-dichlophenol indophenol. The method has been adopted as Final Action for the determination of ascorbic acid in vitamin preparations and juices by the Association of Official Analytical Chemists (AOAC, 1984). By the AOAC procedure, the concentration of ascorbic acid in the sample was calculated thus:

Milligram (mg) ascorbic acid per gram (g) (or per ml) of sample = (X-B) x (F/E) x (V/Y)

where

X = average titre (ml) for sample titration

B = average titre (ml) for sample blank titration

F = mg ascorbic acid equivalent to 1.0ml dye solution, i.e. mg ascorbic acid in aliquot of standard solution titrated divided by the average corrected titre for the standardization titration.

E = amount (g or ml) of sample

V = volume (ml) of initial assay solution

Y = volume (ml) of sample aliquot titrated.

2.5. DETERMINATION OF EMPTY CRATE WEIGHT, EMPTY CRATE VOLUME AND EMPTY CRATE DIMENSIONS

The weight, volume and various dimensions of each of the small and big crates from the different sources (Tono, Vea, Akumadan and Agogo) were determined. All determinations were in triplicate. For weight determination, the "shen chan" weighing scale was used, whilst the carpenters' tape-measure was used for the determination of volume and various dimensions. Readings were recorded in cubic centimetres(cm^3) for volume, centimetres (cm) for dimensions and kilograms (kg) for weight.

3.2.3. EXPERIMENT 3: DEVELOPMENT AND EVALUATION OF THE IMPROVED WOODEN CRATE

The design criteria for the improvement of the existing wooden crate was specifically based on packaging fresh tomato fruits. The new packaging unit was accordingly constructed **(3.3.3)** and evaluated **(3.3.4).** Parameters considered for the evaluation were determination of damage factors as slight physiological, slight mechanical, slight

pathological and sound fruits. Others were shelf-life, firmness and mean fruit weight determination. No chemical analysis was carried out for the fruits.

3.3.1. EXPERIMENTAL DESIGN AND ANALYSIS

A one factor completely randomized design (CRD) was used. The single factor was crate-type. All determinations were in triplicate. Data obtained from the experiments were statistically analysed using computer MSTAT programme. Differences between treatment means were separated using Least Significant Difference (LSD) Test.

3.2. DESIGN AND CONSTRUCTION

Prior to the construction and evaluation of the new package design, a feasibility study was conducted among various stakeholders of the tomato industry including carpenters, wholesalers, retailers, farmers, tomato traders association executives etc. in the Kumasi metropolis. The aim of the preliminary study was to conscientise and create the awareness among these stakeholders in order that their impressions about the new design would be grasped. The construction and evaluation of the design was then commenced and effected.

One design was considered and outlined.

The construction of the packaging unit was carried out at the Department of Agricultural Engineering, KNUST Kumasi.

3.3.3. MATERIALS USED AND METHOD OF FASTENING

The materials used in the construction of the packaging unit included timber {Of*ramu (Terminalia superba)*} –2.54cm x 7.64cm x 365.76cm wood, 2.54 cm nails and 5.08cm nails.

The dimensions for the newly designed packaging unit were:

External Dimensions (cm)		**Internal Dimensions (cm)**	
Length	62	Length	54
Width	41	Width	37
Height	44	Height	43

as recommended by International Labour Organization (ILO) that the optimal length to width ratio should be about 1.5:1 (Wills *et al.*, 1998)

The sides of the crate are joined to the bottom plate by nails. A middle plate is provided. This divides the contents of the box into two equal parts. Two wooden bars are nailed along the mid points of the two lengths of the crate to act as a seat for the middle plate. Two wooden bars were provided at the top of the crate near the extremes, to reduce damage that the contents of the lower part would have endured as a result of stacking.

The newly developed packaging unit was illustrated as Figure 1.

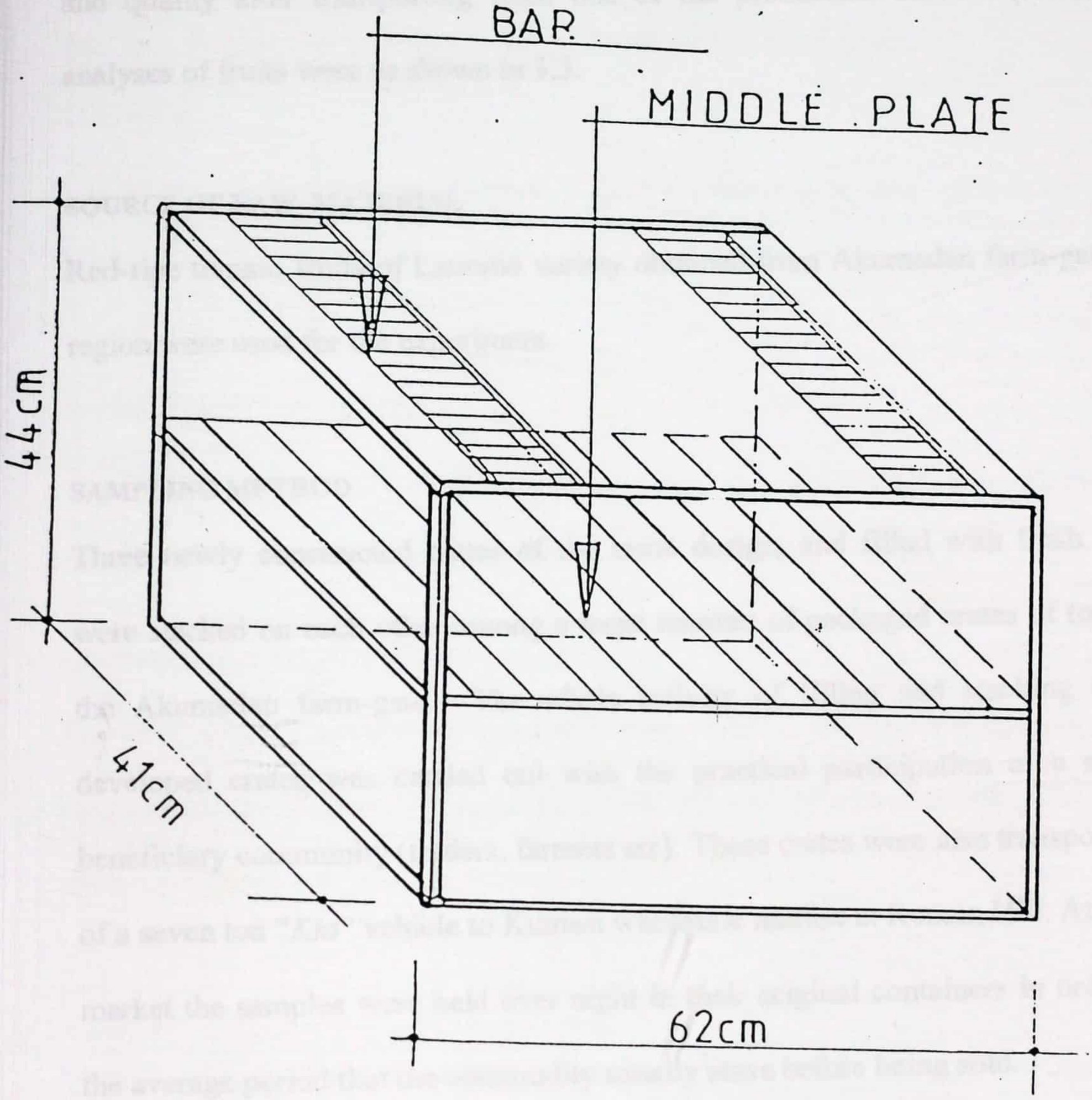


FIGURE 1. IMPROVED WOODEN CRATE FOR TRANSPORTING FRESH TOMATO FRUITS

3.3.4. IMPROVED WOODEN CRATE EVALUATION

The newly designed packaging unit was evaluated by assessing damaged fruit percentage and quality after transporting from one of the production sources (Akumadan). The analyses of fruits were as shown in 3.3.

4.1. SOURCE OF RAW MATERIAL

Red-ripe tomato fruits of Laurano variety obtained from Akumadan farm-gate in Ashanti region were used for the experiment.

.4.2. SAMPLING METHOD

Three newly constructed crates of the same design, and filled with fresh tomato fruits were stacked on each other among a large number of packaged crates of tomato fruits at the Akumadan farm-gate. The whole activity of filling and stacking of the newly developed crates was carried out with the practical participation of a section of the beneficiary community (traders, farmers etc). These crates were also transported by means of a seven ton "*Kia*" vehicle to Kumasi wholesale market at Roman Hill. At the wholesale market the samples were held over night in their original containers in order to simulate the average period that the commodity usually stays before being sold.

After this holding time the samples were also transported to the laboratory, Kwame Nkrumah University of Science and Technology (KNUST) for analysis.

4.0 RESULTS

The results of the studies are presented in Tables 6 to 58 under the different parameters investigated. The results cover a survey report, evaluation of the existing wooden crate and, improvement and evaluation of the developed wooden crate.

4.1 SURVEY

The survey results for the assessment of farmers, wholesalers and retailers are presented in Tables 6-47

4.1.1 ASSESSMENT OF FARMERS

Assessment of farmers was done by studying their background, age, educational status and system of farming practised.

.1.1.1 BIODATA AND BACKGROUND OF FARMERS IN THE TOMATO GROWING AREAS (AKUMADAN, AGOGO, TONO AND VEA)

The sex profile of the farmers shows that males formed the predominant group (91.7%) in the production of tomato compared with females who form about 8.3% (Table 6). Even in the case of Tono, all respondents were males.

Table 6 SEX PROFILE OF FARMERS

SEX PROFILE	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
MALE	28	29	33	31	121	91.7
FEMALE	5	4	0	2	11	8.3
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

Farmers actively involved in this industry were within the age bracket of 21-40 years, specifically the youth (Table 7). Over 83% were below 40 years; 6% were over 50 years and 3.8% below 20 years. This reflected in the educational status of most of the respondents where about 60% of the farmers had either completed Middle School or Junior Secondary School, with 19.7% of them making it to the Primary School level. Only 2.2% had had post secondary education, while 10.6% were completely illiterate.

TABLE 7: AGE DISTRIBUTION OF FARMERS (YEARS)

AGE PROFILE OF FARMERS	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
11 – 20	2	1	1	1	5	3.8
21 – 30	15	16	16	17	64	48.5
31 – 40	9	10	11	11	41	31.1
41 – 50	5	4	3	2	14	10.6
51 – 60	1	2	2	2	7	5.3
> 60	1	0	0	0	1	0.7
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

The land tenure system in operation in the tomato production areas surveyed is mostly that of rented/hired plots (88.6%) with only 4.5% and 6.8% of the farmers cultivating on their own plots and family plots respectively (Table 9). For Tono and Vea none of the respondents cultivated tomato on his or her own plot. They all worked on either a rented or family plot. This is reflected in the general average size (0.92 hectare) of tomato farm manned by an individual farmer.

TABLE 8 EDUCATIONAL STATUS OF FARMERS

EDUCATIONAL STATUS OF RESPONDENT	NUMBER OF RESPONDENTS				TOTAL	PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA		
ILLITERATE	3	4	4	3	14	10.6
PRIMARY	6	7	7	6	26	19.7
MIDDLE SCH.	19	21	20	21	81	61.4
SEC. SCH.	3	1	1	3	8	6.1
POST. SEC.	2	0	1	0	3	2.2
TOTAL	33	33	33	33	13.2	100.0

TABLE 9 LAND TENURE SYSTEM PRACTISED BY FARMERS

LAND TENURE SYSTEM OF AREA	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
RENTED	29	28	29	31	117	88.6
OWN PLOT	3	3	0	0	6	4.6
FAMILY PLOT	1	2	4	2	9	6.8
TOTAL	33	33	33	33	132	100.0

The average tomato farm sizes are 0.7 ha, 0.6 ha, 1.3 ha and 1.2 ha per head for Akumadan, Agogo, Tono and Vea farmers respectively.

With regard to experience in farming the following mean figures were recorded: respondents in Akumadan area reported an average of 18.8 years for being in general farming and 12 years for being in tomato farming; respondents in Agogo reported 15.1 years for being in general farming and 11.4 years for being in tomato farming; respondents in Tono reported 18.6 years for being in general farming and 7.9 years for

being in tomato farming while respondents in Vea reported 18.6 years for general farming and 9.8 years for tomato farming.

.2 AGRONOMIC PRACTISES, EXTENSION SERVICES AND FINANCE SOURCES OF FARMERS

All farmers interviewed responded that tomato is grown on raised beds, mostly three times in a year for farmers in Akumadan and Agogo

(Table 10). For farmers in Tono and Vea, the number of cropping times per year is once, that is during the dry season. However, about 24% of the farmers interviewed in Akumadan and Agogo crop twice in a year.

TABLE 10. NUMBER OF CROPPING TIMES PER YEAR PRACTISED BY FARMERS

CROPPING TIMES OF FARMERS	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
ONCE	0	1	33	33	67	50.8
TWICE	8	8	0	0	16	12.0
THRICE	24	24	0	0	48	36.4
FOUR TIMES	1	0	0	0	1	0.8
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

TABLE 11. DIFFERENT PERIODS OF TOMATO PRODUCTION IN A YEAR IN AKUMADAN AREA.

SEASON	LOCAL TERM	PERIOD
Irrigation	Pumping Machine	Dec./Jan – April
Major	Abrebra	February – June
Second Major	Awiah	July – November
Minor	Petra	Nov. – February

TABLE 12. VARIETIES CROPPED BY FARMERS

TOMATO VARIETIES CROPPED	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
Power	15	14	3	2	34	25.8
Laurano	11	12	10	9	42	31.8
Italy	3	3	2	2	10	7.6
Rasta	1	1	0	0	2	1.5
Roma	2	0	0	0	2	1.5
Cocoa	0	1	0	0	1	0.8
"no name"	0	0	13	14	27	20.5
Pectomech	0	0	4	5	9	6.8
Others	1	1	1	1	4	3.0
Total	**33**	**33**	**33**	**33**	**132**	**100.0**

Several varieties of tomato are cultivated by the farmers. The predominant ones according to the percent respondents indicated in Table 12 are Laurano (31.8%) and Power (25.8%) for farmers in Ashanti region and, "*no name*" (20.5%) and Pectomech (6.8%) for farmers in Upper East region. There were other varieties including Italy, Rasta, Roma, Cocoa, Akuma, etc. grown by few farmers.

TABLE 13. LABOUR TYPE EMPLOYED BY FARMERS

LABOUR CATEGORY	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
Family	2	4	2	3	11	8.3
Friends	0	0	3	4	7	5.3
Hired	31	29	28	26	114	86.4
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

From the survey, hired hands were the main labour used for farming activities (Table 13). These formed a mean of 86.4% of the total help for farmers.

TABLE 14. SOURCE OF SEED FOR FARMERS

SOURCE OF SEED	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
Own Collection	20	22	16	17	75	56.8
Friends	11	10	1	2	24	18.2
Seed dealers	2	1	9	8	20	15.2
FASCOM	0	0	7	6	13	9.8
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

Whereas the source of tomato seeds for production was mostly obtained from farmers' own collection (56.8), friends (18.2%) and other seed dealers also provided tomato seeds for farmers (Table 14). Table 14 again shows that some farmers (9.8%) in Tono and Vea obtained tomato seeds from the Farmers' Services Company (FASCOM) in the Upper East region.

The results of the study showed that all respondents were involved in the use of different kinds of agrochemicals. These ranged from the application of the conventional fertilizers comprising mainly NPK 15 –15 –15, NPK 20-20-0, Sulphate of Ammonia and urea to other chemicals such as Samppi, Unden, Karate, Dithane, Topsin, Champion and the like.

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TABLE 15. SOURCE OF WATER FOR TOMATO CROPS

WATER USED	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
gation Dam	10	0	33	33	76	57.6
nfed, streams, ngs and land areas ng the river ks	23	33	0	0	56	42.4
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

Water source for tomato production has been largely rain-fed, streams, springs and lowland areas along the river-banks (42.4%) for farmers in Akumadan and Agogo. However, 30% of the farmers interviewed in Akumadan had access to irrigation dam facilities (Table 15).

Table 15 also shows that water source for tomato production in the Tono and Vea areas was mainly by their respective irrigation dams. All the farmers interviewed reported of the presence of health disorders in their tomato crops. These included nematode infestation, mould attacks, fruit cracks, pests, flower drop and reduced fruit size. However, about 72% of the respondents had been exposed to regular extension officer visits leaving about 28% of them who had erratic visits of the Extension Officers (Table 16).

TABLE 16. EXTENSION OFFICER VISITS

FREQUENCY OF EXTENSION OFFICER VISIT	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
REGULAR	26	10	30	29	95	72
IRREGULAR	7	23	3	4	37	28
TOTAL	**33**	**33**	**33**	**33**	**132**	**100**

Table 17 shows that the majority of the farmers were self-financed (85.6%) while a small number of them got credit from the bank (4.5%) and money lenders (6.1%). Others like family members, relatives, spouses and friends also played a role as financial sources (3.8%), but rather on the low side.

TABLE 17. SOURCE OF FINANCE FOR FARMERS

SOURCE OF FUNDING	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
Own money	25	27	32	29	113	85.6
Money lender	3	4	0	1	8	6.1
Bank loan	2	0	1	3	6	4.5
Others	3	2	0	0	5	3.8
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

4.1.1.3 HARVESTING PROCEDURES

All farmers determined harvest maturity by colour of the fruit. They all did manual harvesting and harvested when the fruits were red-ripe with the majority of the labourers either untrained (83.3%) or had undergone casual training (16.7%) (Table 18).

TABLE 18 TRAINIING OF LABOURERS PRIOR TO HARVESTING

SKILL OF LABOUR	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
Untrained	26	28	27	29	110	83.3
Casually trained	7	5	6	4	22	16.7
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

With regard to the time of the day harvesting is done, most of the farmers indicated that they harvest only when the traders had arrived and a price had been agreed upon. As such harvesting was carried out anytime of the day (65.1%) (Table 19). However, a few of the respondents specified that they harvested in the morning (19.7%) and others indicated the evening (15.2%) as their usual time of harvest.

TABLE 19 THE TIME OF THE DAY HARVESTING IS DONE

HARVESTING TIME	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
Morning	6	7	6	7	26	19.7
Evening	5	6	4	5	20	15.2
Anytime of the Day	22	20	23	21	86	65.1
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

From the study, the mode of harvest was mainly by collecting fruits into smaller containers (aluminum bowls and pans, woven baskets, plastic containers, small crates etc.) and transferring it into the traders containers (usually wooden crates). In the Upper East Region some of the harvesting containers included smaller baskets made from guinea corn stalks, calabashes and hats.

The buyers' or traders' containers were loaded straight into waiting trucks or vans (62.9%) but where the roads were unmotorable, produce was conveyed in head-load and left by the road-side (16.7%) for the traders to pick them up (Table 20). In other few cases the fruits were sent to the village market (20.4%) usually in baskets and pans immediately after harvesting.

ABLE 20 IMMEDIATE POST-HARVEST ACTIVITIES

CTION AFTER HARVEST	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
ruits are sent to ıe road side.	8	6	5	3	22	16.7
ruits are sent to ıe village narket.	5	13	3	6	27	20.4
ruits are loaded traight into Vaiting vehicles	20	14	25	24	83	62.9
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

1.1.1.4 PACKAGING, TRANSPORTATION AND MARKETING PRACTISES

Post-harvest storage activities undertaken by the producers as revealed by the study was very minimal. Virtually none of the respondents carried out on-farm or any form of storage of tomato fruits after harvesting or prior to sales at the farm level. The type of post harvest activity carried out by the producers could best be described as packaging, which occurs only just after harvesting the fruits. All respondents attested to the fact that there was the need to standardize the volume of the wholesale wooden crate. It has also been found from the survey that farmers have always filled the containers to the brim without adequate sorting/grading for transportation.

According to the study, producers and traders have always employed untrained labourers to do packaging and stacking. The study also indicated that farmers sold their produce

mostly at the farm-gate (75%) with 17.4% and 7.6% of respondents who did sales at the village market and home station respectively (Table 21).

TABLE 21: PLACE WHERE TOMATO FRUITS ARE SOLD

VENUE FOR SALE OF PRODUCE	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
Farm-gate	24	19	29	27	99	75.0
Home station	3	5	1	1	10	7.6
Village market	6	9	3	5	23	17.4
TOTAL	**33**	**33**	**33**	**33**	**132**	**100.0**

As to problems of post harvest linked to tomato production, less than half of the respondents (47%) felt that they had post-harvest problems and these were mainly linked to fruit handling (Table 22). This is reflected in the proportion of producers (53%) who responded that they had no post harvest problems (Table 22).

TABLE 22: FARMERS' PERCEPTION OR RESPONSE TO POSTHARVEST PROBLEMS

VALUE LABEL	NUMBER OF RESPONDENTS					PERCENT RESPONDENT
	AKUMADAN	AGOGO	TONO	VEA	TOTAL	
Yes	16	15	15	16	62	47
No	17	18	18	17	70	53
TOTAL	**33**	**33**	**33**	**33**	**132**	**100**

4.1.2 ASSESSMENT OF WHOLESALERS

In the production and marketing chain of tomato fruits, wholesalers are the link between the producers and the retailers. In an attempt to assess wholesalers as part of the exercise to determine the existing status and trend of fresh tomato fruit packaging in Ghana, one hundred and five respondents (wholesalers) were interviewed. The following are the results.

BIODATA AND BACKGROUND OF WHOLESALERS

The survey results show that wholesaling of fresh tomato fruits was mostly carried out by the females (88.6%) with the rest being males (11.4%)(Table 23).

TABLE 23: SEX PROFILE OF WHOLESALERS

SEX STATUS	NO. OF RESPONDENTS	PERCENT RESPONDENT
Male	12	11.4
Female	93	88.6
TOTAL	**105**	**100.0**

The survey also indicated, that illiterates (41.9%) form the majority of the wholesalers followed by middle school leavers/junior secondary school leavers (29.5%), then primary school leavers (21.9%) and a few senior secondary school leavers (6.7%) (Table 24). The majority are within the age bracket of 21-50 years (92.5%) (Table 25).

TABLE 24: EDUCATIONAL STATUS OF WHOLESALERS

EDUCATIONAL STATUS OF WHOLESALERS	NO. OF RESPONDENTS	PERCENT RESPONDENT
Illiterate	44	41.9
Primary School	23	21.9
Middle School	31	29.5
Secondary School	7	6.7
TOTAL	**105**	**100.0**

Most of the wholesalers have been in trade (tomato wholesaling) for a range of six to fifteen years (Table 26). All the respondents attested to the fact that tomato fruit wholesaling is an all year round trade for them.

TABLE 25: AGE DISTRIBUTION OF WHOLESALERS (YEARS)

AGE RANGE	NO. OF RESPONDENTS	PERCENT RESPONDENT
11 – 20	3	2.8
21 – 30	28	26.6
31 - 40	43	41.0
41 – 50	26	24.8
51 – 60	5	4.8
TOTAL	**105**	**100.0**

TABLE 26: NO. OF YEARS IN TOMATO WHOLESALE TRADE

PERIOD OF TRADING	NO. OF RESPONDENTS	PERCENT RESPONDENT
1 – 5	18	17.1
6 – 10	32	30.5
11 – 15	28	26.7
16 – 20	14	13.3
21 – 25	10	9.5
> 25	3	2.9
TOTAL	**105**	**100.0**

Table 27 shows that there were various reasons for entering into the tomato wholesale trade. These ranged from unemployment (39%) which is the predominant cause, to girl child trade, family business and the desire to get money.

TABLE 27: REASON (S) FOR GOING INTO TOMATO WHOLESALING

REASONS FOR TRADING	NO. OF RESPONDENTS	PERCENT RESPONDENT
Girl child trade	32	30.5
Desire to get money	14	13.3
Uemployment	41	39.1
Family business	18	17.1
TOTAL	**105**	**100.0**

4.1.2.2 TOMATO SALES, SOURCE AND HANDLING

Several varieties of the tomato fruits were traded by the wholesalers. Some of the varieties included Power, Rano, Roma, Laurano, '*no name*', Pectomech, Paul, Italy, Rasta, Caterpillar, Akuma, Cocoa, Asante, Navrongo, Bolga, Zuarungu, etc.

All respondents indicated that the fresh tomato fruits were usually purchased red-ripe from producers at the farm-gate (91.4%) and sometimes at the village market or home station (8.6%) (Table 28). Wholesalers obtained the fresh tomato fruits from the farm-gates/village markets/home stations of Tono, Vea, Zuarungu, Akumadan, Agogo, Dormaa, Derma, Kumawu, Offinso, Techiman, Mampong, Sege, etc, and some producing areas in Burkina Faso e.g. Quagla, Karifugu, Zinyari and Yaako.

TABLE 28. SOURCE OF TOMATO SUPPLY TO WHOLESALERS

SOURCES OF SUPPLY	NO. OF RESPONDENTS	PERCENT RESPONDENT
Farm-gate	96	91.4
Village market or Home Station	9	8.6
TOTAL	**105**	**100.0**

The wholesalers usually bought the fresh tomato fruits on volume basis, usually packaged in wooden crates. These were usually conveyed by a variety of transport including '*Kia*' the most predominant vehicle (67.7%) employed (Table 29) to their destinations.

TABLE 29: VEHICLE TYPE EMPLOYED BY WHOLESALERS

TRANSPORT TYPES	NO. OF RESPONDENTS	PERCENT RESPONDENT
Articulators	4	3.8
Small mummy trucks	5	4.8
Big mummy trucks	14	13.3
Closed vans	8	7.6
Kia vehicles	71	67.6
Others	3	2.9
TOTALS	**105**	**100.0**

The respondents gave different comments about the packaging container (i.e. the wooden crate) for distribution of the fresh tomato fruits (Table 30).

TABLE 30: WHOLESALERS' COMMENTS ON WOODEN CRATE

ACCEPTANCE OF WOODEN CRATES	NO. OF RESPONDENTS	PERCENT RESPONDENT
Alright	30	28.6
Should be stronger and collapsible	21	20.0
Not be abrasive	20	19.0
Allow more ventilation	24	22.9
Standardize size	10	9.5
TOTAL	**105**	**100.0**

All respondents interviewed indicated that the crates containing the fresh tomato fruits were not stuffed with other accessory materials during transportation to their destinations, but they all agreed that crates were always over-filled (i.e. filled to the brim for transportation).

The majority (61%) of the wholesalers indicated that they did not transport tomato fruits with other goods but some (39%) agreed that they did (Table 31).

TABLE 31: TRANSPORTATION OF TOMATO FRUITS WITH OTHER GOODS BY WHOLESALERS

VALUE LABEL	NO. OF RESPONDENTS	PERCENT RESPONDENT
Yes	41	39
No	64	61
TOTAL	**105**	**100**

All the respondents also attested to the fact that labourers were not trained prior to packaging and stacking. They also indicated that damages occurred during transportation mostly at the bottom and during sales. The damages occur mostly at the bottom, then the top and even sometimes the damages were distributed throughout the crate (Table 32).

TABLE 32: DISTRIBUTION OF FRUIT DAMAGES WITHIN THE CONTAINER AS TRANSPORTED BY WHOLESALERS

POSITION OF DAMAGE IN CRATE	NO. OF RESPONDENTS	PERCENT RESPONDENT
Top	35	33.3
Bottom	53	50.5
Distributed	17	16.2
TOTAL	**105**	**100.0**

All respondents indicated that damages had a link with the variety of tomato fruits transported and also with the poor road net-work. However, a section of them (7.6% and 15.2%) disagreed that damages had a link with package type and, mode of filling and stacking respectively (Tables 33 and 34).

TABLE 33: DAMAGE LINKED TO PACKAGE OR CONTAINER AS ASSESSED BY WHOLESALERS

DAMAGE CAUSED BY CONTAINER	NO. OF RESPONDENTS	PERCENT RESPONDENT
Yes	97	92.4
No	8	7.6
TOTAL	**105**	**100**

TABLE 34: DAMAGE LINKED TO MODE OF FILLING AND STACKING AS ASSESSED BY WHOLESALERS

DAMAGE CAUSED BY STACKING	NO. OF RESPONDENTS	PERCENT RESPONDENT
Yes	89	84.8
No	16	15.2
TOTAL	**105**	**100.0**

All respondents indicated that there was neither adequate sorting, grading nor storage carried out at the farm-gate or wholesale stage of the fresh tomato fruit business.

4.1.2.3 SOCIO-ECONOMIC STATUS OF WHOLESALERS

Table 35 indicates that the majority of the wholesalers financed their businesses themselves (76.2%). However, family sourcing and bank loans were other means of finance at the disposal of some of the wholesalers. Some respondents also reported that they had additional businesses to the tomato fruit trade which supported them financially.

TABLE 35: SOURCE OF FINANCE FOR THE WHOLESALER

TRADER FINANCE	NO. OF RESPONDENTS	PERCENT RESPONDENT
Own money	80	76.2
Family money	17	16.2
Bank loan	2	1.9
Others	6	5.7
TOTAL	**105**	**100.0**

l respondents attested to the fact that they did encounter problems in the business. Some of ese problems included poor road net-work, high transport costs, inconsistent produce prices, ıreliable vehicles for transport and high perishability rate of fresh tomato fruits during ɔmmercial handling and transportation.

1.3 ASSESSMENT OF RETAILERS

In the assessment of retailers, one hundred and thirty three respondents were interviewed. This total comprised eighty eight and forty five respondents from Ashanti and Upper East regions respectively.

3.1 BIODATA AND BACKGROUND OF RETAILERS

The results of the survey indicated that retailers were mainly females. Most of these women were either illiterate (36.8%) or have had basic school education (Table 36). The majority of them were also within the age bracket of 21-40 years (79.6%) (Table 37).

TABLE 36: EDUCATIONAL STATUS OF RETAILERS

RETAILERS EDUCATION	NO. OF RESPONDENTS	PERCENT RESPONDENT
Illiterate	49	36.8
Primary	38	28.6
Middle School	26	19.5
Secondary School	20	15.1
TOTAL	**133**	**100.0**

TABLE 37: AGE DISTRIBUTION OF RETAILERS (YEARS).

AGE RANGE	NO. OF RESPONDENTS	PERCENT RESPONDENT
11 – 20	7	5.3
21 – 30	41	30.8
31 – 40	65	48.8
41 – 50	13	9.8
> 50	7	5.3
TOTAL	**133**	**100.0**

Most of the retailers interviewed had been in the trade for more than fifteen years (41.3%)(Table 38). However, all respondents attested to the fact that tomato fruit retailing was an all year round business for them.

From the survey it was indicated that there were various reasons for going into tomato retail trade (Table 39). These range from unemployment (39.1%) which was the predominant cause, to girl child trade (26.3%), family business (18.8%) and the desire to earn money (15.8%).

TABLE 38: EXPERIENCE IN RETAIL TRADE

PERIOD FOR TRADING (YEARS)	NO. OF RESPONDENTS	PERCENT RESPONDENT
1 – 5	25	18.8
6 – 10	36	27.1
11 – 15	17	12.8
16 – 20	52	39.1
> 20	3	2.2
TOTAL	**133**	**100.0**

TABLE 39: REASONS FOR GOING INTO RETAIL TRADE

RETAILING TRADE – REASONS	NO. OF RESPONDENTS	PERCENT RESPONDENT
Girl Child Trade	35	26.3
Desire to earn money	21	15.8
Unemployment	52	39.1
Family business	25	18.8
TOTAL	**133**	**100.0**

.3.2 TOMATO SALES, SOURCE AND HANDLING BY RETAILERS

Several varieties of fresh tomato fruits were being traded by the retailers. Some of the varieties peculiar with the Kumasi area retailers

included Power, Asante, Laurano, Bolga, Caterpillar, Roma, Cocoa, Navrongo, Techimantia, Zuarungu and Akuma. For the Bolgatanga area retailers, the peculiar varieties included Pectomech, "*no name*", Paul, Power, Laurano, Zuarungu, Navrongo, Italy, Clement and Bolga.

The retailers bought the fresh tomato fruits when they were in the red-ripe stage. This was usually one day (64.7%), two days (25.5%) or three days (9.8%) after harvest (Table 40).

TABLE 40: NO. OF DAYS AFTER HARVEST RETAILERS BUY PRODUCE

INTERVAL BETWEEN HARVEST AND SALES	NO. OF RESPONDENTS	PERCENT RESPONDENT
One day	86	64.7
Two days	34	25.5
Three days	13	9.8
TOTAL	**133**	**100.0**

The major sources of the fresh tomato fruits for the Kumasi area markets included Akumadan, Agogo, Kumawu, Derma, Dormaa, Mampong, Techiman, Offinso, Afrancho, Tono, Vea and

some producing areas in Burkina Faso eg. Quagia, Karifugu, Zinyari and Yaako. For the Bolgatanga area markets in the Upper East region, the major sources of the fresh tomato fruits were Tono, Vea, Akumadan, Zuarungu, Yikini, Techiman, etc. and the same areas in Burkina as mentioned earlier.

Retailers buy from wholesalers on volume basis. The majority of the retailers (88%) received the fresh tomato fruits in wooden crates. However some of them received the fruits in both wooden crates and local woven baskets (12%) (Table 41).

TABLE 41: RETAIL- WHOLESALE STAGE CONTAINERS USED.

WHOLESALE/RETAIL CONTAINERS	NO. OF RESPONDENTS	PERCENT RESPONDENT
Wooden Crate	117	88
Wooden Crate/basket	16	12
TOTAL	**133**	**100**

Various comments were made about the wooden crate by the respondents (Table 42).

TABLE 42: RETAILERS' COMMENTS ON WOODEN CRATE

REACTION TO WOODEN CRATES	NO. OF RESPONDENTS	PERCENT RESPONDENT
Alright	61	45.9
Depends on middle-men	39	29.3
Reduce size	33	24.8
TOTAL	**133**	**100.0**

From the survey, 87.2% of the respondents did not agree that the crates containing the fresh fruits were sometimes stuffed, but about 13% of them accepted in good faith that the loaded crates were sometimes stuffed with grasses (Table 43).

TABLE 43: STUFFING FILLED-CRATES WITH OTHER ACCESSORIES AS INDICATED BY RETAILERS

STUFFING IN CRATES	NO. OF RESPONDENTS	PERCENT RESPONDENT
Yes	17	12.8
No	116	87.2
TOTAL	**133**	**100.0**

All respondents interviewed attested to the fact that there were damages during transportation from the farm-gate to the market and during sales. They added that the damages usually occurred at the bottom and at the top with traces at the sides, and that sometimes the damages were evenly distributed in the crate. They also indicated that the extent of damage had a link with the variety of the tomato fruit, package type, mode of filling the package and stacking techniques.

Irrespective of the high perishability of the fresh tomato fruit, no chemical inputs (preservatives) were applied by the retailers after purchase i.e. in an attempt to extend the shelf-life.

All retailers interviewed did sorting/grading in one way or the other before sales.

On the average most of the retailers sold between six and ten crates of fresh tomato in a week (Table 44). A few are able to sell above ten crates (15.8%) but only about 11.3% sold between 1 and 5 crates.

TABLE 44: QUANTITY SOLD PER WEEK BY RETAILERS (NO. OF CRATES)

NO. OF CRATES SOLD PER WEEK	NO. OF RESPONDENTS	PERCENT RESPONDENT
1 to 5	15	11.3
6 to 10	97	72.9
> 10	21	15.8
TOTAL	**133**	**100.0**

SOCIO-ECONOMIC STATUS OF RETAILERS

Table 45 indicates that many of the retailers (39.9%) buy on credit and retail. This is followed by 26.3% of the respondents who are able to do the retail trade with their own money. Other respondents (18.8%) do retailing with parents money and only about 15% of them had access to bank loans.

TABLE 45: SOURCES OF FINANCE FOR RETAILERS

SOURCE OF FINANCE	NO. OF RESPONDENTS	PERCENT RESPONDENT
Own money	35	26.3
Parent money	25	18.8
Bank loan	20	15.0
Buys on credit	53	39.9
TOTAL	**133**	**100.0**

1.4 TOMATO MARKETING PARTICIPANTS AND ORGANISATION

The urban marketing system for vegetables is handled by the private sector. The public sector institutions such as the Ghana Food Distribution Corporation have not been involved in vegetable marketing. The system is characterised by a very large number of small scale traders who are almost all women. The size of their marketing enterprises is limited by capital and hardships encounted in trading vegetables.

Traders who do well, often move out of vegetable marketing when they have enough capital to invest in other trading businesses that do not require travelling.

.4.1 TOMATO MARKETING PARTICIPANTS

Table 46 shows the different participants in the marketing operations for fresh tomato fruits in Ghana.

TABLE 46: MARKETING PARTICIPANTS IN FRESH TOMATO FRUITS IN GHANA.

TYPE	DESCRIPTION
1. Urban Market oriented farmers.	Older women and young men who sell to itinerant traders. Greater use of agro-chemicals, irrigation and mono-cropping.
2. Consumption and local market oriented farmers.	Women who grow on a small scale for home consumption and sell any left over. Intercropped, use very little inputs.
3. Urban based itinerant traders.	Buy direct from farmers and local assemblers. Sell in main urban markets.
4. Rural based itinerant traders.	Buy from local farmers and transfer to urban centres.
5. Rural local assemblers.	Based in villages and rural towns. Buy from farmers, bulk up and sell to itinerant traders/local market retailers.
6. Rural retailers	Farmers who sell their own produce in a village, rural town or roadside market.
7. Transporters.	Drivers and assistants of lorries and vans that travel to producing areas.
8. Porters	Load and unload tomato crates, carry to selling point and to retailers' stalls.
9. Commission agents and elders.	Sell on behalf of itinerant traders and farmers who are not members of the traders' association in that town.
10. Retailers	Buy from itinerant traders and commission agents. Sell from a stall.
11. Hawkers	Work with retailers and carry produce around market or around houses-children or paid workers of retailers.

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.1.4.2. ORGANISIZATION OF THE TOMATO FRUIT MARKET IN GHANA

According to the survey findings the organization of the market for tomato fruit business is accomplished by the complementary efforts of bargaining with farmers, customer-trader relationships, farmer associations, trader associations and co-operation in price setting.

The market structure comprises of the market and information channels that enhance the vegetable industry. With regard to the marketing infrastructure, transport and types of market were found to be the two most important areas needing concern to facilitate the fresh tomato fruit business.

4.2 EXISTING WOODEN CRATE EVALUATION

Based on the survey findings an evaluation was carried out on the wooden crates (small and big sizes), including a subjective analysis of the appropriateness of the package design (style and construction), dimensions and the types of materials commonly used. Labels, ventilation exits and accessories were also considered. In addition, physical and chemical tests were carried out in the laboratory to evaluate the post-harvest losses and quality changes in the fresh tomato fruit after subsequent commercial handling and transportation in the crates.

4.2.1 ANALYSIS OF THE APPROPRIATENESS OF THE PACKAGE DESIGN

Observations indicate that provision had not been made for even and adequate distribution of ventilation within and between the crates after stacking. Provision had also not been made to protect produce at the bottom of the stack from the pressure exerted from packages above. The types of packaging materials used were '*wawa*' (*Triplochiton scleroxylon*) and 'Kyenkyen' (*Antiaris toxicaria*) wood. Packages also were without labels

except for the identification marks of owners. There were also no accessories lining crates for internal protection.

Data on package dimensions, empty package weight and volume are presented in Tables 47 and 48.

TABLE 47: PACKAGE DIMENSIONS WITH REGARD TO LOCATION AND CRATE TYPE.

LOCATION	PACKAGE SIZE	INTERNAL LENGTH (cm)	INTERNAL WIDTH (cm	INTERNAL HEIGHT (cm)	EXTERNAL LENGTH (cm)	EXTERNAL WIDTH (cm)	EXTERNAL HEIGHT (cm)
Tono	Small	52.00 c	41.23 a	41.00 cd	60.20 a	45.17 cd	43.77 a
	Big	64.03 a	48.20 a	46.97 a	73.00 a	52.03 a	49.50 a
Vea	Small	51.93 c	42.00 a	41.23 c	61.00 a	46.00 c	44.00 a
	Big	64.00 a	48.30 a	47.17 a	73.50 a	51.00 b	49.00 a
Akumadan	Small	53.00 b	41.47 a	42.00 b	61.00 a	45.00 d	44.17 a
	Big	64.00 a	48.00 a	46.80 a	73.10 a	52.00 a	50.00 a
Agogo	Small	51.00 d	42.03 a	40.40 d	60.27 a	46.00 c	43.50 a
	Big	64.07 a	48.50 a	47.27 a	73.40 a	51.27 ab	49.00 a
CV(%)		0.59	0.69	0.83	0.55	0.90	0.65

Mean separation by Duncan's Multiple Range Test.

Means within each column with different letters are different significantly ($P<0.05$).

Table 47 shows the dimensions of different crate-sizes as found in the four locations. The internal lengths of the small crates transported from Akumadan (53.00cm) were significantly ($P<0.05$) longer than those transported from Agogo (51.00cm). However, the internal lengths of the small crates transported from Tono and Vea, which were 52.00cm and 51.93cm respectively, did not differ significantly but were significantly ($P<0.05$) shorter than those from Akumadan (53.00cm) and significantly ($P<0.05$) longer than those from Agogo (51.00cm). The internal length measurements for the big crates were 64.03cm, 64.00cm, 64.00cm and 64.07cm for crates transported from Tono, Vea, Akumadan and Agogo respectively but were not significantly different from one another.

The internal widths of the small crates across the four locations ranged from 41.23 cm to 42.03cm, while the internal width measurements for the big crates ranged from 48.00cm to 48.50cm.The external length measurements for the small crates ranged from 60.20cm to 61.00cm whiles those of the big crates ranged from 73.00 cm to 73.50 cm. The external height measurements of the smaller crates ranged from 43.50cm to 44.17cm whereas those of the big crates ranged from 49.00cm to 50.00 cm. The external width measurements of the small crates ranged from 45.00 cm to 46.00 cm, while those of the big crates ranged from 51.00 cm to 52.03 cm.

TABLE 48: EMPTY CRATE VOLUME AND WEIGHT WITH REGARD TO LOCATION AND CRATE TYPE.

LOCATION	PACKAGE SIZE	VOLUME (m^3)	WEIGHT (kg)
Tono	Small	0.088 de	7.80 a
	Big	0.145 ab	10.50 a
Vea	Small	0.090 cd	7.75 a
	Big	0.146 ab	9.80 a
Akumadan	Small	0.092 c	8.00 a
	Big	0.144 b	10.25 a
Agogo	Small	0.087 e	7.40 a
	Big	0.147 a	10.18 a
CV (%)		1.14	3.27

Mean separation by Duncan's Multiple Range Test.

Means within each column with different letters are different significantly ($P<0.05$).

Table 48 shows the different empty volumes and empty weights of the two crate sizes transported from the four locations. Volume capacities differed among the small crates, eg. the empty crate volume of the small crates transported from Agogo ($0.087m^3$) was significantly ($P<0.05$) smaller than that transported from Akumadan ($0.092\ m^3$). The empty crate weight differences ranged from 7.40kg to 8.00kg for the small crates and, 9.80kg to 10.50kg for the big crates (Table 48) but the differences were not statistically significant ($P>0.05$).

4.2.2 PHYSICAL ANALYSIS OF TOMATO FRUITS

Parameters for analyses included: percent distribution of various types of damaged tomato fruits, fresh tomato fruit shelf-life, fruit firmness and mean tomato fruit weight.

WHOLESALE MARKET WITH REGARDS TO SOURCE AND CRATE SIZE.

SOURCE	CRATE SIZE	SOUND FRUITS		NATURE OF DAMAGE								TOTAL % DAMAGED
				PHYSIOLOGICAL		MECHANICAL		PATHOLOGICAL		COMPLETELY SQUASHED		
		WEIGHT (kg)	%	WEIGHT (kg)	%	WEIGHT (kg)	%	WEIGHT (kg)	%	WEIGHT (kg)	%	
Tono	Small	19.82 h	34.96 d	14.67 f	25.87 b	9.85 f	17.37 d	5.02 c	8.86 b	7.34 c	12.95 c	65.05
	Big	23.37 e	29.51 e	21.09 a	26.63 a	14.25 c	17.99 d	7.52 a	9.50 a	12.96 b	16.36 b	70.48
Vea	Small	20.98 g	35.53 d	15.67 e	26.53 ab	10.34 f	17.51 d	5.01 c	8.49 c	7.05 c	11.94 c	64.47
	Big	22.37 f	29.02 e	20.44 b	26.52 ab	14.00 c	18.16 d	6.42 b	8.33 c	13.86 a	17.98 a	70.99
Akumadan	Small	31.80 d	51.17 b	12.85 g	20.67 d	12.42 e	19.98 b	4.27 e	6.87 d	0.81 e	1.30 e	48.82
	Big	38.25 a	47.17 c	19.20 c	23.68 c	17.01 b	20.98 b	4.76 d	5.87 e	1.87 d	2.31 de	52.84
Agogo	Small	33.63 c	54.39 a	12.21 h	19.75 e	13.27 d	21.46 b	2.72 g	4.40 f	0.00 e	0.00 f	45.61
	Big	36.89 b	46.40 c	16.49 d	20.74 d	20.58 a	25.88 a	3.16 f	3.97 g	2.39 d	3.01 d	53.60
CV (%)		0.79%	1.06%	1.57%	1.06%	1.94%	1.37%	1.29%	1.31%	5.19%	4.96%	

Mean separation by Duncan's Multiple Range Test.

Means within each column with different letters are significantly different (P>0.05)

4.2.2.1 PERCENT DISTRIBUTION OF VARIOUS TYPES OF DAMAGED TOMATO FRUITS AT THE KUMASI WHOLESALE MARKET WITH REGARD TO SOURCE AND CRATE SIZE

The results in Table 49 show that the amount of sound fruits transported to the Kumasi wholesale market differed significantly with respect to both crate size and source. The magnitudes of sound fruits in the small crates were 19.82kg, 20.98kg, 31.80kg and 33.63kg for Tono, Vea, Akumadan and Agogo respectively. For the big crates, the magnitudes of sound fruits were 23.37kg, 22.37kg, 38.25kg and 36.89kg for Tono, Vea, Akumadan and Agogo respectively. There was thus a significantly ($P<0.05$) higher amount of sound fruits in the small crates than in the big crates for each of the sources. There was even much higher amount of sound fruits in the small crates transported from Akumadan and Agogo when considered on percentage basis.

Most of the damage factors differed significantly ($P<0.05$) in their magnitudes with regard to both crate size and source. The magnitudes of the physiologically damaged, mechanically damaged, pathologically damaged and fruits that were completely squashed with respect to small crates were: 14.67kg, 9.85kg, 5.02kg and 7.34kg respectively for Tono; 15.67kg, 10.34kg, 5.01kg and 7.05kg respectively for Vea; 12.85kg, 12.42kg, 4.27kg and 0.81kg respectively for Akumadan; and 12.21kg, 13.27kg, 2.72kg and 0.00kg respectively for Agogo. The magnitudes of the damage factors in the same order with respect to the big crates were: 21.09kg, 14.25kg, 7.52kg and 12.96kg respectively for Tono; 20.44kg, 14.00kg, 6.42kg and 13.86kg respectively for Vea; 19.20kg, 17.01kg, 4.76kg and 1.87kg respectively for Akumadan; and 16.49kg, 20.58kg, 3.16kg and 2.39kg respectively for Agogo.

Most of the damages encounted were physiological, followed by mechanical and pathological in that order.

The percentage of completely squashed fruits was significantly ($P<0.05$) higher in crates transported from Tono and Vea than in crates from Akumadan and Agogo.

TABLE 50: SHELF-LIFE, FIRMNESS AND MEAN WEIGHT OF TOMATO FRUITS PACKAGED AT DIFFERENT LOCATIONS AND TRANSPORTED TO THE KUMASI CENTRAL MARKET.

SOURCE	SHELF-LIFE (DAYS)	FIRMNESS (SCORE)	MEAN FRUIT WEIGHT (g)
Tono	4.28 b	2.99 c	64.13 a
Vea	4.37 b	2.90 bc	60.53 c
Akumadan	5.82 a	2.61 ab	62.98 b
Agogo	5.88 a	2.52 a	51.73 d
CV (%)	5.67	9.92	0.60

Mean separation by Duncan's Multiple Range Test.

Means within each column with different letters are different significantly ($P<0.05$).

4.2.2.2 SHELF-LIFE, FIRMNESS AND MEAN TOMATO FRUIT WEIGHT DETERMINATION

The results in Table 50 show that the shelf-life of tomato fruits after being packaged and transported to the Kumasi wholesale market from the different sources ranged between 4.28 and 5.88 days.

The shelf-life of fruits transported from Tono (4.28 days) and Vea (4.37 days) was significantly ($P<0.05$) shorter than those transported from Akumadan (5.82 days) and Agogo (5.88 days). The longest shelf-life, close to 6 days, was recorded for fruits transported from Akumadan and Agogo whereas the shortest shelf-life (just over 4 days) was recorded for fruits from Tono and Vea.

Firmness score ranged between 2.5 and 3.0 for all the fruits transported from the different sources (Table 50). Those with least score values were firmer than those with higher scores according to the scoring scale (3.2.2.3.3).

Fruits from Agogo recorded the least score of 2.5 implying it was the firmest among all the different sources after being transported to the Kumasi wholesale market. This was, however, not significantly ($P>0.05$) different from the score (2.61) obtained by fruits transported from Akumadan but was significantly ($P<0.05$) firmer than the rest of the fruits transported from the other sources.

Fruits transported from Tono and Vea recorded the highest firmness scores of 2.99 and 2.90 respectively. There was a negative correlation ($r=-0.52^*$) between ripe fruit firmness and its shelf-life, i.e., shelf-life days decreased with increasing ripe fruit firmness score and vice versa. There was also a significant correlation ($r=0.78^*$) between crate size and ripe fruit firmness. This also implies that as crate size increases, ripe fruits firmness score also increases and vice versa. Crate size correlated weakly ($r=-0.15$) with shelf-life probably suggesting that crate size has only a little effect on shelf-life.

The results also show that the mean fruit weight for all the different sources ranged between 51.7g and 64.1g with fruits from Tono recording the highest mean fruit weight of 64.1g. This was significantly ($P<0.05$) heavier than fruits from Vea, Akumadan and Agogo. However, fruits from Agogo had the least mean fruit weight of 51.7g. This was followed by fruits from Vea (60.5g) and Akumadan (62.9g) in that order.

Mean tomato fruit weight correlated positively ($r=0.30^*$) with its firmness but was not statistically significant ($P<0.05$). However, there was a negative correlation ($r=-0.52^*$) between mean tomato fruit weight and its shelf-life.

TABLE 51: SHELF-LIFE, FIRMNESS AND MEAN TOMATO FRUIT WEIGHT DETERMINATION WITH REGARD TO CRATE SIZE.

CRATE SIZE	SHELF-LIFE (DAYS)	FIRMNESS (SCORE)	MEAN FRUIT WEIGHT (g)
Small	5.21a	2.38a	59.87a
Big	4.97a	3.12b	59.82a
CV (%)	5.67	9.92	0.60

Mean separation by Duncan's Multiple Range Test.

Means within each column with different letters are different significantly ($P<0.05$).

The results in Table 51 show that the shelf-life (5.21 days) of fruits transported in small crates to the Kumasi wholesale market did not differ significantly ($P>0.05$) from the shelf-life (4.97 days) of those transported in big crates. All the same there was a slight preponderance of the former over the latter.

The results also show that fruits transported in small crates were significantly ($P<0.05$) firmer than those transported in big crates. The highest firmness score was recorded for small crates (2.3) whereas the least was recorded for big crates (3.1).

There was no difference in the mean fruit weight as transported in the different crate sizes.

The mean fruit weight in each case was about 60g.

TABLE 52: SHELF-LIFE, FIRMNESS AND MEAN TOMATO FRUIT WEIGHT DETERMINATION WITH REGARD TO CRATE SIZE AND SOURCE.

SOURCE	CRATE SIZE	SHELF-LIFE (DAYS)	FIRMNESS (SCORE)	MEAN FRUIT WEIGHT (g)
Tono	Small	4.40 a	2.48 a	63.86 ab
	Big	4.17 a	3.49 a	64.40 a
Vea	Small	4.63 a	2.40 a	60.27 d
	Big	4.10 a	3.39 a	60.79 d
Akumadan	Small	5.87 a	2.33 a	62.59 c
	Big	5.77 a	2.88 a	63.37 b
Agogo	Small	5.93 a	2.30 a	52.76 e
	Big	5.83 a	2.73 a	50.70 f
CV (%)		5.67	9.92	0.60

Mean separation by Duncan's Multiple Range Test.

Means within each column with different letters are different significantly ($P<0.05$).

There were no differences in the shelf-life of fruits with regard to both crate size and source (Table 52). The shelf-life for fruits transported in the small crates were 4.40, 4.63, 5.87 and 5.93 for Tono, Vea, Akumadan and Agogo respectively, whereas the shelf-life for fruits transported in the big crates were 4.17, 4.10, 5.77 and 5.83 for Tono, Vea, Akumadan and Agogo respectively (Table 52).

The interaction of crate size and source did not yield any significant difference in fruit firmness (Table 52). The firmness scores across the different crate sizes and different sources ranged from 2.73 to 3.49 for big crates and 2.3 to 2.48 for small crates. There were significant ($P<0.05$) differences in mean fruit weight across the different crate sizes and the different sources (Table 52). The highest mean fruit weight (64.40g) was recorded for fruits transported from Tono, whereas fruits transported from Agogo recorded the lowest mean fruit weight (50.70).

The mean fruit weight of fruits transported in the small crates were 63.86g, 60.27g, 62.59g and 52.76g for Tono, Vea, Akumadan and Agogo respectively, whilst the mean fruit weight for those transported in the big crates were 64.40g, 60.79g, 63.37g and 50.70g respectively for the different sources in the same order (Table 52).

4.2.3 CHEMICAL ANALYSES OF TOMATO FRUITS

This was accomplished by determining percent Tritratable acidity, total soluble solids, reducing sugars, ascorbic acid and pH contents of the samples.

TABLE 53: CHEMICAL ANALYSES OF TOMATO FRUIT SAMPLES FROM THE KUMASI WHOLESALE MARKET.

SOURCE	CRATE SIZE	CHEMICAL QUALITY FACTOR				
		pH	% Titratable acidity	% Total Soluble Solids	% Reducing Sugars	Ascorbic acid (mg/1000g fresh weight)
Tono	Small	4.35a	0.61a	4.36a	3.61bc	19.90a
	Big	4.29a	0.59a	4.22a	3.49c	19.85a
Vea	Small	4.30a	0.61a	4.45a	3.90a	23.11a
	Big	4.34a	0.60a	4.30a	3.50bc	23.15a
Akumadan	Small	4.15a	0.65a	4.54a	3.86a	25.23a
	Big	4.31a	0.62a	4.39a	3.67b	25.30a
Agogo	Small	4.19a	0.64a	4.51a	3.84a	25.50a
	Big	4.27a	0.63a	4.60a	3.97a	25.56a
CV (%)		1.77	2.31	1.15	4.09	3.18

Mean separation by Duncan's Multiple Range Test.

Means within each column with different letters are different significantly ($P<0.05$)

4.2.3.1 PERCENT TITRATABLE ACIDITY, TOTAL SOLUBLE SOLIDS, REDUCING SUGARS, ASCORBIC ACID AND pH CONTENT

Results in Table 53 showed that the interactive effect of source and crate size did not indicate any significant difference ($P>0.05$) in percentage titratable acidity, percentage total soluble solids, ascorbic acid and pH content of the fruits after analysis. However, the content of reducing sugars in fruits transported from Agogo was significantly higher as compared to those transported from Tono in both crate sizes. The percentage reducing sugars in fruits transported from Agogo to Kumasi wholesale market in the small and big crates were 3.84 and 3.97 respectively, whereas the percentage reducing sugars in fruits transported from Tono to Kumasi wholesale market in the small and big crates were 3.61 and 3.49 respectively (Table 53).

Reducing sugars content in fruits transported in the small crates from Vea and Akumadan were significantly ($P<0.05$) higher when compared to those transported in the big crates. The content of reducing sugars in fruits transported in the small and big crates from Vea were 3.90 and 3.50 respectively, whereas that transported in the small and big crates from Akumadan were 3.86 and 3.67 respectively (Table 53).

4.3 IMPROVED WOODEN CRATE EVALUATION

The results of the experiments set up to evaluate the improved wooden crate for packaging tomato fruits are presented in Tables 54 to 57.

Table 54 shows the mean dimensions of the different crate-sizes transported from Akumadan farm-gate to the Kumasi wholesale market. The three different crates differed significantly ($P<0.05$) from each other in their internal width, internal height, external length and external width measurements. The ranges for the internal width, internal height, external length and external width measurements for the three different crate sizes were 37.00cm to 48.00cm, 42.00cm to 46.81cm, 61.00cm to 73.10cm and 41.00 cm to 52.00cm respectively. For the internal length and external height measurements, the small crate and the improved crates did not differ significantly ($P>O.05$) from one another, but were significantly shorter than those of the big crate. The internal lengths were 53.67cm and 54.00cm for the small and improved crates respectively while the external heights were 44.15cm and 44.00cm for the small and improved crates respectively. The internal length and external height for the big crate were 64.00cm and 50.00cm respectively. Generally, dimensions were about the same for the small crate and the improved crate (Table 54) with respect to internal length and external height measurements.

TABLE 54: DIMENSIONS OF DIFFERENT CRATE SIZES TRANSPORTED FROM AKUMADAN FARM-GATE TO KUMASI WHOLESALE MARKET.

RATE IZE	DIMENSIONS (cm)					
	INTERNAL LENGTH	INTERNAL WIDTH	INTERNAL HEIGHT	EXTERNAL LENGTH	EXTERNAL WIDTH	EXTERNAL HEIGHT
mall	53.67	41.45	42.00	61.00	45.00	44.15
ig	64.00	48.00	46.81	73.10	52.00	50.00
nproved	54.00	37.00	43.00	62.00	41.00	44.00
SD (0.05)	1.56	0.76	0.59	0.61	0.82	0.60

Mean separation by Least Significant Difference (LSD) Test.

Table 55 shows the empty volume and weight measurements of the different crate sizes (small, big and improved crates) transported from Akumadan farm-gate to the Kumasi wholesale market. The volume of the improved crate was significantly ($P<0.05$) smaller than that of the small and big crates. The volume of the small crate was, however, significantly ($P<0.05$) smaller than that of the big crate as empirically expressed. The various volumes were 0.092 m^3, 0.144m^3 and 0.086m^3 for the small crate, big crate and the improved crate respectively. The big crate had the highest volume of 0.144 m^3 while the improved crate had the smallest volume of 0.086m^3 .

There were no significant differences ($P>0.05$) in weight measurements between the small crate and the improved crate, but weight measurements of these crates (small & improved crates) were significantly ($P<0.05$) lower than that of the big crate (Table 55). The weight measurements for the small, big and improved crates were 8.00 kg, 10.25kg and 8.35 kg respectively. The big crate had the heaviest weight of 10.25 kg whiles the small and improved crates were of lesser weights (8.00kg and 8.35kg respectively).

TABLE 55: EMPTY CRATE VOLUME AND WEIGHT MEASUREMENTS OF DIFFERENT CRATE SIZES TRANSPORTED FROM AKUMADAN FARM-GATE TO KUMASI WHOLESALE MARKET.

CRATE SIZE	VOLUME (m^3)	WEIGHT (Kg)
Small	0.092	8.00
Big	0.144	10.25
Improved	0.086	8.35
LSD (0.05)	0.002	0.65

Mean separation by Least Significant Difference (LSD) Test.

The results in Table 56 show that the quantity of each damage factor differed significantly ($P<0.05$) in the different crate sizes. Produce in the improved crate recorded the highest percentage (91.09%) of sound fruits after transportation. This was followed by the small crate (51.17%) and then the big crate (47.17%).

For all treatments the intensity of the damages in a descending order were physiological, mechanical, pathological and those that were completely squashed. The quantities of the produce that were physiologically damaged were 12.85kg, 19.20kg and 3.07kg for the small, big and improved crates respectively while mechanically damaged fruits were 12.42 kg, 17.01kg and 1.53 kg for the small, big and improved crates respectively. Those that were damaged due to pathogen infection were 4.27 kg, 4.76 kg and 0.067kg for the small, big and improved crates respectively.

The big crate recorded the highest percentage of produce that was completely squashed (2.31%). This was followed by 1.30% of completely squashed produce in the small crate while produce in the improved crate was entirely free of completely squashed fruits (Table 56).

TABLE 56: PERCENTAGE DISTRIBUTION OF VARIOUS TYPES OF DAMAGED TOMATO FRUITS IN DIFFERENT CRATE SIZES TRANSPORTED FROM AKUMADAN FARM-GATE TO KUMASI WHOLESALE MARKET.

CRATE SIZE	SOUND FRUITS		NATURE OF DAMAGE								TOTAL % DAMAGED
			PHYSIOLOGICALLY DAMAGED		MECHANICALLY DAMAGED		PATHOLOGICALLY DAMAGED		COMPLETELY SQUASHED		
	WEIGHT (Kg)	%	WEIGHT (Kg)	%	WEIGHT (Kg)	%	WEIGHT (Kg)	%	WEIGHT (Kg)	%	
Small	31.80	51.17	12.85	20.68	12.42	19.98	4.27	6.87	0.810	1.30	48.83
Big	38.25	47.17	19.20	23.68	17.01	20.98	4.76	5.87	1.87	2.31	52.84
Improved	47.73	91.09	3.07	5.86	1.53	2.93	0.07	0.13	0.00	0.00	8.92
LSD (0.05)	0.60		0.90		0.37		0.15		0.45		

Mean separation by Least Significant Difference (LSD) Test.

Data on shelf-life, ripe-fruit firmness and mean fruit weight for the small crate, big crate and the improved crate are presented in Table 57.

The shelf-life of fruits contained in the three different crate sizes ranged between six and twelve days after transportation. The shelf-life of fruits transported in the small and big crates were significantly ($P<0.05$) shorter than those transported in the improved crate.

Some of the fruits shrivelled during the storage period before deterioration. Fruit rot during the storage period was higher among fruits transported in the small and big crates. It was also observed that the rate of deterioration was faster in big sized fruits than the small ones. Those fruits with the calyx attached also deteriorated faster than those without the calyx during the experimental period.

Firmness score ranged between 1.067 and 2.880 for all fruits transported in the three different crate sizes. Those with least score values were firmer than those with higher scores according to the scoring scale. The fruits transported in the improved crate recorded the least score of 1.067 implying that those fruits were the firmest among the fruits transported in the different crates (Table 57). The fruits in the big crate recorded the highest score of 2.880 meaning those fruits were relatively soft. The fruits in the small crate which ranked in between those of the improved and big crates recorded a score of 2.330, suggesting that they were firmer than those transported in the big crate but relatively softer than those transported in the improved crate.

The mean weight of fruits transported in the three different crate sizes ranged between 62.59g and 63.37g with fruits in the big crate recording the highest weight of 63.37g. This weight (63.37g) was significantly ($P<0.05$) higher than the weight obtained for fruits transported in the small and improved crates (62.59g and 62.60g respectively) (Table 57).

TABLE 57: SHELF-LIFE, RIPE-FRUIT FIRMNESS AND MEAN TOMATO FRUIT WEIGHT DETERMINATION WITH REGARDS TO DIFFERENT CRATE SIZES TRANSPORTED FROM AKUMADAN FARM-GATE TO KUMASI WHOLESALE MARKET

CRATE SIZE	SHELF-LIFE (DAYS)	RIPE-FRUIT FIRMNESS (SCORE)	MEAN FRUIT WEIGHT (g)
Small	5.867	2.330	62.59
Big	5.767	2.880	63.37
Improved	11.967	1.067	62.60
LSD (0.05)	0.231	0.466	0.27

Mean separation by Least Significant Difference (LSD) Test

5.0 DISCUSSION

The results of the experiment have been discussed under three major topics, being the survey, evaluation of existing packages and the improved wooden crate.

5.1 THE SURVEY

5.1.1 ASSESSMENT OF FARMERS

Assessment of farmers in an attempt to determine the types of packaging methods used in Ghana is discussed below.

5.1.1.1 BIODATA AND BACKGROUND OF FARMERS

Male domination in tomato farming (Table 6) may be attributed to the labour intensive nature of tomato cultivation in Ghana. The high male percentage is also due to the fact that in most of these farming communities the most economically viable venture opened to the male youth is farming, specifically tomato farming. This assertion holds because 79.6% of farmers actively involved in tomato production are within the age group of 21 – 40 years (Table 7), specifically the youth. This is also reflected in the educational status of most of the respondents where more than sixty percent (60%) of the farmers had either completed Middle School (standard four) or Junior Secondary School (J. S. S.) with only a few reaching the primary school level (Table 8). Lyon *et al.* (1996) reported that most vegetable production was done by women, often intercropping within other crops and using most for home consumption while selling any surpluses in the nearby markets. They, however, indicated that more men became involved as the access to markets increased, especially in the irrigated areas. Thus the

numbers of vegetable producers continued to increase as many young men started farming due to unemployment (Lyon *et al.*, 1996).

Reasons for the high tomato farming activities on rented plots (Table 9) may include the issue of land ownership. In Ghana, land is vested in the hands of few indigenous inhabitants and families. Another reason may be that many of the tomato farmers are migrant farmers who have the habit of not farming at the same area for quite a long time. The other reason may be for proximity. For instance, Lyon *et al.* (1996) reported that the location of a farm affects the marketing opportunities as traders will prefer to go to those areas that are more accessible or where many farmers are producing in close proximity. This allows the trader to save time and cost. Therefore farmers often hire land near the road, even if they have access to good land that is farther away.

The choice of the sample areas is justified since tomato farming in the areas has been persistent (about 11 years).

5.1.1.2 AGRONOMIC PRACTICES, EXTENSION SERVICES AND FINANCE SOURCES AVAILABLE TO FARMERS

Tomato is generally grown on raised beds and this enhances efficient use of water commonly applied as furrow irrigation.

The majority of the respondents in Akumadan and Agogo cultivate tomato three times in a year with a few cropping twice a year. These cropping times have been possible perhaps due to the fact that Akumadan and Agogo fall in the transitional zone (guinea savannah) and the forest zone (semi-deciduous) respectively, although in many areas the division between the zones is unclear, with the invasion of Savannah species due to degradation of the forest areas (Lyon *el al.*, 1996). In Akumadan for instance, four cropping times namely, irrigation, major, second major and minor seasons have been identified. The details are obtained in Table 11. This is not different from what

pertains in Agogo. Production of tomato in these two areas is thus an all year round business.

This has been possible also because farmers in Akumadan and Agogo depend on rain water, irrigation dam (few farmers around Akumadan), springs, streams and residual moisture for the dry season production. The rainy season in the forest area is between March and November with a break for a short time in July – August. In the transitional zone the rains start later and finish earlier and may not have a noticeable gap (Lyon *et al.*, 1996). The situation in the Upper East Region is different. Thus, for farmers in Tono and Vea, the number of cropping times per year is once (Table 10) and that is during the dry season. This is because, the same land is used during the rainy season for other food crops like maize, millet, soya beans, etc. There are only two clear-cut seasons in the north and for that matter Upper East Region (Tono and Vea). These are the rainy season (April to October) and the dry season (November to March) (Appendix Table 1).

Farmers indicated that the varieties they cultivated were most preferred due to their firm texture, thus, their ability to have longer shelf-life and also stand the stress of handling just as indicated by Olympio *et al.* (1998). Some farmers alternate the varieties – such as Caterpillar with Power or Rano and Italy with Power.

Farmers often grow some Rasta variety among the preferred varieties, as it is a bigger size fruit and so "fills the crate quickly", although the traders find it too watery. The amount of mixing allowed can vary over the season, with the trader being more lenient in the periods of scarcity. If there are too many of the unpopular varieties, then the price can be bargained down. For the choice of variety, Lyon *et al.* (1996) asserted that farmers can and do also choose those varieties that allow them to maximise their

income and reduce the level of risk. To achieve this, farmers consider pre-harvest factors that affect the marketing of the tomato fruit. These include the length of the harvest period, early or late maturing and resistance to water stress when the rains have finished. This is important when there is shortage of traders visiting a producing area for a few days. The introduction of new varieties with better postharvest qualities are therefore restricted by the need to satisfy a wide range of other criteria that are set by the farmers and traders.

Hired labour was the main source for tomato farming activities. This may be attributed to the fact that respondents were all commercial farmers and hence the need to hire labour to meet the required efforts needed to maximise profits.

The source of seed for tomato production was mostly from farmers' own collection (Table 14). In support of this finding, Lyon *et al.* (1996) reported that in a survey of vegetable farmers, it was found out that 73% of tomato farmers used seed from their own collection. This guaranteed a sure supply of seed to farmers for the following season's production. It also enabled farmers to save money and to help other farmers. Fruit for seed is usually picked at the middle or end of the harvest period. However, many farmers and traders extract seed from fruit that could not be sold. Farmers develop "customer" relationships with some traders and part of this relationship is the provision of seed.

Generally, farmers' reasons for applying agrochemicals included: increase in yield, prevention of diseases and insect pests or both, etc., but in most cases weed control was not part of the reasons. On the whole it was noticed that there was blatant abuse of agrochemical usage by most of the farmers. For example, when farmers had to wait for a few days for the crop to ripen to the red-ripe stage especially during periods that they

think they will be missing good marketing opportunities, they resorted to using abusive alternatives such as spraying with a cocoa fungicide, "cocobre", on tomato crops (Sherrington and Suglo, 1994). This makes many of the leaves fall off, the fruits ripen quickly, while giving the tomato a thick skin. In addition to the dangers the fungicide poses to consumers, traders complained that the shelf-life of the tomato fruit thus treated was reduced (Sherrington and Suglo, 1994).

Akumadan and Agogo are situated in the transitional and forest zones respectively (Lyon *et al.*, 1996). The climatic locations of these two areas may have made the different water sources possible to their farmers, thus, enhancing an all year round production. As to the lower percentage of the respondents indicated to have their farms watered by the constructed irrigation dam in Akumadan, Zamani (2000) reported that it is because most of the machines planted for the running of the irrigation dam had broken down for the past seven years with no response whatsoever from any quarters for their rehabilitation. Water source for Tono and Vea areas was mainly by their respective dams, since they were the only convenient sources available for commercial tomato production at the time.

The nematode infestation and other hazards on the tomato crop by other pests may be attributed to the absence of the practice of crop rotation and lack of farm sanitation respectively in some of the production areas. Mould attacks, flower drop and reduced fruit size may be attributed to climatic reasons (Norman, 1992). For instance a farmer in Tono stated that "when flowering occurred during Christmas (cold period) a bumper harvest was realized but when flowering occurred during the warmer weather there was much flower drop and thus low harvests." However, Warburton and Lyon (1995) reported that the presence of crop health disorders may be attributed to the blatant

abuse of agrochemicals by most of these farmers who were urban market oriented and were involved in a greater use of agrochemicals and mono-cropping.

A higher percentage of the Extension Officer visits recorded could be to protect the image of the Extension Staff as some of them were involved in the questionnaire administration. It is usually the responsibility of the Agricultural Extension Officer to liase between research and the farmer in order that farmer problems are addressed.

Generally farmers were self-financed but it was much more common for small amounts of credit in the form of cash or inputs to come from the traders with whom the farmers have built up a "customer" relationship. This credit is usually repaid at harvest time. However, some farmers simply did not cherish bank loans for fear of crop failure or something similar, which might lead to debts.

5.1.1.3 HARVESTING OF TOMATO FRUITS BY FARMERS

The high percentage of the untrained labour is because the employers or producers assume that the labourers they hire have experience in growing and harvesting tomato and so expect that there is going to be no damage or less damage done to the picked fruits, and more importantly to the plants. The availability and cost of labour, distance to market, intended use, factory capacities, price and demand for a crop all influence the manner and number of harvests or the decision to harvest (Villareal, 1980; Swiader *et al.*, 1992). Thus, the farmers harvest at the red-ripe stage upon demand by the traders (Lyon *et al.*, 1996), although there is a risk of damage to the fruit through squashing, splitting and deterioration in quality during transportation to the market. In the markets, the red-ripe fruit was preferred and traders sold the produce immediately.

In most circumstances, the fruits were harvested during the day, transported to the market overnight and sold to retailers the next morning. The retailers would then sell

to consumers through out the day. Consumers normally prefer those that are red-ripe as they buy frequently, everyday or every other day. Another reason was that traders would get a much lower price for unripe fruits, besides they would have no where to store produce to be allowed to ripen. Further more, they want to get their working capital back quickly so that they could return to the producing areas.

Ideally, harvesting should be done in the morning or evening when the fruits were cooler. In many circumstances this may not be possible as the farmers would not harvest until the traders had arrived and a price had been agreed upon. This is reflected in the higher percentage (65%) (Table 19) of farmers who indicated harvesting any time of the day. In some cases the traders would come to the farm in the morning and harvesting will be done in the middle of the day so that the traders could leave in the evening and reach the market the next morning. In some cases, most of the farmers harvest in the morning as buyers would arrive in the night or dawn. To avoid harvesting particularly during mid-day when temperatures would be unreasonably high, it is necessary to demonstrate the benefits of harvesting at the correct or ideal time of the day to the traders and to the farmers alike.

In many cases there would be no shade at where the produce would be left for the traders to pick, and the crate would be left without cover or partially covered with leaves or cloth. This, thus, would expose the produce to high ambient temperatures, which would reduce the shelf-life (Bonte-Friedheim, 1989). The urban based as well as the rural based itinerant traders bought the fruits in these baskets and pans and transferred them into their containers (usually wooden crates). The rural local assemblers and the rural retailers on the other hand could choose to buy and at the

same time sell the fruits in the same baskets and pans – sometimes even in smaller containers.

As mentioned already, the tomato fruits were picked or harvested red-ripe but a small number of less ripe fruits may be acceptable and were put at the bottom of the traders' crate. Lyon *et al.* (1996) reported that the lack of ventilation would make them ripen sooner.

Some retailers especially those who sell by the highways would like to have some less ripe ones which they can sell over a longer period. The traders preferred to buy tomato fruits with the calyx left on as they believed that this would allow the fruits to last longer and look nicer to the consumer. However, farmers/traders need to be exposed to the fact that the calyx left on fruits could be a source of physical damage to the fruits in transit, especially in the containers.

5.1.1.4 PACKAGING, TRANSPORTATION AND MARKETING PRACTICES OF FARMERS

Due to the high perishability and lack of adequate preservation techniques for the fresh tomato fruit, there is very little storage practised in the post-harvest system. Farmers will not harvest until they have a buyer and so storage is usually on the plant. At certain times farmers may have small quantities of tomato fruits that they have harvested and could not sell. In such rare cases they may keep the produce on a concrete floor in a dark room. Some farmers in Akumadan believe that this practice keeps the fresh tomato fruits free from spoilage for at least the next few days. Package and packaging expenditure is a shared cost between the wholesaler and the farmer respectively. Packaging is predominantly carried out in wooden crates and this is usually preceded by bias sorting. This type of sorting, only separates the big fruits from the small fruits so that the smaller fruits can be placed underneath the container,

thus exposing the bigger fruits to attract customers or to give the impression that all the fruits were big sized.

All the farmers agreed that there was the need to standardize the volume of the wholesale wooden crate so that the traders would not manipulate the size at their (farmers) expense. They also reported that the crates were always filled to the brim upon the demand of the traders as any damaged fruits could still be sold. Bigger ripe ones would be placed along the gaps or ventilation exits in the crate and nice looking fruits of the preferred varieties placed on the top. This is also a way of hiding poor quality produce, thus confirming that adequate on-farm sorting is not carried out. The amount of lower quality produce in the crate could also depend on the amount of produce that is ready for harvesting. A farmer is usually compelled to fill the crate with lower quality produce where there is not enough good quality ones to avoid the risk of the price being cut due to the smaller quantity.

The trader or someone the trader trusts has to inspect the produce as it is being packed into the crate and when it is also loaded into the vehicle. This may explain why the itinerant traders prefer to travel to the producing areas themselves rather than rely on buying agents to send the produce to them. Some traders even go to the farm to insist on good quality although farmers try to avoid this as more produce is rejected. Farmers sometimes employed untrained labourers for both packaging and stacking on the assumption that the labourers have been doing tomato work and for that matter are experienced. Farm-gate sales, as do most producers are much patronised by the urban-based itinerant traders while the village market and home station sales take care of the rural-based itinerant traders, rural local assemblers and the rural retailers. The rural-based itinerant traders are in many cases vegetable growers themselves or wives of vegetable growers (Lyon *et al.*, 1996).

At the farm-gate, the unit of sale is by volume (i.e. volume of the crate) and farm-gate price is determined by both the producer and the trader depending on season, demand, and availability of produce. The farmer, however, would control the market then or at least would have a comparative bargaining advantage during the period of scarcity. The trader on the other hand commands the market only during periods of glut. This is because the bargaining power balance between the farmer and trader changes from time to time. In periods of scarcity the farmers can set the price and the traders will have to buy as there may not be other places to go to. In periods of glut the farmers cannot afford to bargain as the traders have the power to go elsewhere for the same produce. In such a case the farmers would have a very weak bargaining position and so traders would determine the price.

The call for permanent purchasing outlets for tomato fruits, standardization of the crate's volume and the stabilization of the unit price for a crate of tomato fruits though, was an issue of great importance to the farmers.

5.1.2 ASSESSMENT OF WHOLESALERS

5.1.2.1 BIODATA AND BACKGROUND OF WHOLESALERS IN THE STUDY AREA

Wholesaling of fresh tomato fruits is carried out by both males and females (Table 23), unlike that of retailing where only women are involved in the trade. Though marketing of the produce is almost all done by women especially the established itinerant traders selling in the south of Ghana, traders in the north of Ghana can be both men and women. This is because occasionally men act as middlemen or wholesalers when the traders cannot pay the farmers on the spot. At certain times of scarcity too, farmers are allowed to sell their produce in the main markets and so both men and women will go to the urban markets and bargain for the prices.

The majority (41.9%) of the wholesalers were illiterate (Table 24) and this may account for the poor packaging practises like the use of the heavy crates, the stacking of the crates too high, over filling the heavy crates, etc., carried out by the wholesalers. Also because of the high illiteracy rate of the wholesalers, Clark (1994) proposed that traders may not want to change the units of sale as they have developed the skills in calculating profit and any different unit will mean a risk in miscalculating the price.

The majority of the wholesalers were within the age group of 21 – 50 years (Table 25) and have been in trade for a range of period of between six and fifteen years (Table 26) as an all year round business. This assertion may agree with Lyon *et al.* (1996) who stated that there is tomato production throughout the year where there is access to irrigation. This is because since there is production throughout the year and the majority of the traders are those who have been unemployed before, (Table 27), then there is the possibility for respondents to take the trade as an all year round business.

5.1.2.2 TOMATO SALES, SOURCE AND HANDLING BY WHOLESALERS

Power, Laurano, "*No name*" and Pectomech predominant among the several varieties of tomato fruits traded by the wholesalers. Lyon *et al.* (1996) stated that traders' preferences are one of the major influences on the choice of varieties that farmers grow. These varieties may have also dominated because of their firm structure, thus, their ability to have a longer shelf-life and also to stand the stress of handling (Ellis *et al.*, 1997). Awiti – Kuffour *et al.* (2000) also recommended varieties that have firm fruits, do not crack easily, have relatively tough skin and are able to stand adverse field conditions. Examples are Roma VF, Putomic and Laurano 70. Lyon *et al.* (1996) indicated that although there is a risk of damage to the fruit through squashing, splitting and deterioration in quality during transportation to the market and in the market, the red-ripe fruits are preferred as traders usually want to sell the produce

immediately. They added that the consumers buying the produce also prefer those that are red-ripe as they usually buy everyday or every other day. Traders get a much lower price for unripe fruit and they have no place to store produce to allow it ripen. Further more they prefer getting their working capital back quickly so that they could return to the producing areas. Villareal (1980) stated that for processing, tomato fruits were harvested red-ripe and for the fresh market they were harvested at various colour stages. She, however, indicated that the availability of labour as well as the cost of labour, distance to market, intended use, and factory capacities all influenced the manner and number of harvests.

Apart from the selected growing areas wholesalers also bought the fresh tomato fruits from other areas on volume basis usually in wooden crates. Lyon *et al.* (1996) stated that the most common containers used for bulk distribution of tomato fruits are wooden crates and this is decided by the itinerant traders when they collect the produce from the village or farm-gate. If the farmer takes the produce to the market then he or she is able to choose what container to use. The wooden crates are usually conveyed by a variety of transport to their destinations, the most predominant being the open vehicles. These destinations include Accra, Kumasi, Cape Coast, Sekondi – Takoradi, Tema, Koforidua, Obuasi, Sunyani, Techiman, Tamale, Wa, Bolgatanga, Bawku, etc.

The "*Kia*" (a type of open back vehicle) vehicle is the most common means employed in transporting fresh tomato fruits from the farm-gate in Ghana. It has a low body and varied capacity. The types of vehicles employed by the wholesalers are sometimes influenced by their destinations. Clark (1994) indicated that transport used for conveying tomato fruits from the farm-gates ranged from trucks and "mammy

wagons" to smaller vans and even taxis or passenger cars when taking smaller quantities to local markets. Larger vehicles are usually shared between traders (Clark, 1994). Lyon *et al.* (1996) also stated that tomato fruits should be transported in ventilated vehicles. They added that there are a range of vehicles available but some of the smaller ones tend to have poor ventilation. Those traders using them do not have a choice as they cannot hire larger trucks unless they join with other traders. The "*Kia*" vehicle might therefore dominate in the transportation of fresh tomato fruits from the farm-gate because of its make up which enhances better ventilation. Also because of its varied capacity, traders with small capital can always hirer those of smaller volume capacities.

The majority of the traders preferred the big crate. This collective opinion may also agree with Clark (1994) who earlier on proposed that traders may not want to change the units of sale as they have developed the skills in calculating profit and any different unit will mean a risk in mis-calculating the price. Lyon *et al.* (1996) also asserted that even though the big tomato crates used by the farmers and traders can result in more damage to the fruit at the bottom because of the excessive volume of produce, the traders also benefit from having big crates as they can fit a larger quantity of tomato fruits into a vehicle, they can still sell the damaged ones and, there is a reduction in the amount paid on levies per crate. These levies include taxes to district assemblies in the producing area, market fees for municipal authorities or district assemblies, fees/commission to market associations or market queens and pottering charges. The wholesalers discourage the farmers from using the small crate by paying only half the price of the big crate for it though it is more than half the quantity of the big crate.

The practises of stuffing with dry grass and over-filling were observed during the survey. The reason for stuffing was that during the scarce period when very small sized fruits were transported they (the small size fruits) were prevented from falling off the ventilation exits. This particular wholesaler had transported the fruits from Quagia in Burkina Faso. However, crates transported from the local farm-gates are likely not to be stuffed because of proximity.

It was observed that other goods transported with the fresh tomato fruits in the same vehicle included banana, plantain, cassava, avocado, egg plant fruits and citrus. Awiti Kuffour *et al.* (2000) indicated that with mixed load of different commodities, ethylene produced by one product, for example, climacteric ripening fruit such as banana can promote rapid senescence or ripening of another product such as pawpaw, mango, apple etc. Mixed loading is perhaps peculiar with large vehicles such as articulated-trucks or is practised at times when the vehicle in question is not filled to capacity. After numerous crates have been stacked there is still the likelihood that there will be some space in the vehicle, which compels the traders to go in for other commodities to fill the gap. This becomes an additional income to the trader. The practice of mixed loading might be due to ignorance as the majority of the respondents are illiterates.

Labourers hired for packaging and stacking were usually untrained. Traders assume that the labourers might be conversant with the job, since they were employed from the same area. Consequently, poor packaging and stacking resulting in bursting of packages, bruising and squashing of contents occur (Bonte – Friedheim, 1989). It was also observed that damages occurred during transportation and sales.

The assertion that damages had a link with the variety of produce agree with Ellis *et al.* (1997) who stated that the Power variety was mostly preferred due to its firm texture and its ability to have a longer shelf-life and also stand the stress of handling. For damage linked to poor road net-work, Bonte-Friedheim (1989) stated that vibration of the vehicle itself and from rough roads could cause produce to move within a container or wooden crates to come apart. A section of the wholesalers may have disagreed because they have been conservative in the use of the big wooden crate and in the mode of filling and stacking. However, personal observation was that retail traders who were more experienced always stayed away from picking the big crates and those stacked beneath the lot, knowing that more crushed fruits were in the big crates and those stacked beneath the lot. This observation was, however, peculiar with vehicles that arrived from longer journeys such as from Tono, Vea and from other areas in Burkina Faso eg. Quagia, Karifugu, Zinyari and Yaako.

Wholesaler neither did sorting/grading nor storage because they normally would get farmers to fill the crate with the smaller fruits at the bottom of the crate. The bigger ones are usually placed on top to attract customers at the wholesale market. The holding period at the wholesale state is very brief and the only kind of storage carried out is that during transportation or when in transit, after which the produce is sold to the retailers.

5.1.2.3 SOCIO-ECONOMIC STATUS OF WHOLESALERS

Several sources of finance were at the disposal of wholesalers but the majority were self-financed. Some of them interviewed at Tono indicated that they were self-financed simply because of the fear of government loan, especially the fear of being arrested when they defaulted. Thus, the majority of them were without bank credits. On the other hand, it may be that because the majority of the wholesalers were

illiterate they found it cumbersome lobbying for bank credits. Also the issue of family sourcing of finance has been reported by Lyon *et al.* (1996) who observed older traders taking their daughters with them on trading trips so that they could meet the farmers and be able to continue their activities in later days. This was also observed during the present survey.

Some wholesalers had additional businesses perhaps because of the fact that tomato trade is not stable and keeps on fluctuating due to changes in demand and supply. Thus during times of high demand leading to high profits, a trader in some other business could temporally take advantage of that to make some profit (Lyon *et al.*, 1996). However, the call for solutions to identified problems were issues of great concern to the wholesalers.

5.1.3 ASSESSMENT OF RETAILERS

The assessment of retailers have been discussed under the following sub-topics.

5.1.3.1 BIODATA AND BACKGROUND OF RETAILERS

Retailing of fresh tomato fruits is mainly by females. Lyon *et al.* (1996) indicated that before 1970 most vegetable production was done by women, often intercropping within other crops and using most for home consumption while selling any surpluses in near-by markets.

Clark (1994) in her study of Kumasi market traders stated earlier that the dominance of women in the retail sector is due to the lack of any other alternatives, the very small amount of capital needed to start and the very small income that they get from it. She added that those dealing in the more lucrative itinerant trade and buying from the farm-gate tend to have started as retailers. Even earlier, Scarborough (1990) had reported a high concentration of female participants in retailing, and male domination

of wholesaling in Malawi, which suggested barriers other than those directly related to capital requirement. Hence gender influences traders' decisions and activities. However, varying reasons for entering into the tomato trade have been given (Table 39), the predominant cause being unemployment.

5.1.3.2 TOMATO SALES, SOURCE AND HANDLING BY RETAILERS

Several varieties of tomato fruits are being retailed. Lyon *et al.* (1996) indicated that post-harvest losses can be reduced by the use of varieties with better post-harvest qualities. As such traders' preferences influenced the choice of varieties that farmers grow.

The post-harvest qualities of tomato fruits that are required by traders were reported from a subjective evaluation of new varieties by traders in Kumasi and Sunyani (Lyon and Biney, 1996). The results of the evaluation indicated that retailers usually purchased the tomato fruits red-ripe, because conventionally, tomato is harvested for sale at the red-ripe stage in Ghana. Reasons including source and availability of the tomato fruits, means of available transport and the nature of the road net-work cause produce to delay in getting to retailers. In other cases retailers receive produce late because some wholesalers cannot hire their own transport, thus, they would join other traders who might not be ready at the same time. Hence the delay. If the retailers receive the produce any time after a day's harvest (i.e., after about 24 hours), off-farm post-harvest losses increase because fresh tomato fruits are very perishable (Tweneboah, 2000). Fruits become over-ripened (lower quality) because they were harvested at the red-ripe stage and so must be sold for a lower price. Normally, throughout the day the price of fruits

drop as traders compete to sell all the fruits in their crates before fresh produce comes in the next morning. The quality of the tomato fruits declines through the day as there is limited space for shaded storage in the markets.

Produce received in crates and baskets are often sold to traders by urban market oriented farmers and, the consumption and local market oriented farmers respectively (Warburton and Lyon, 1995). Lyon *et al.* (1996) indicated that the most common containers used for bulk distribution are wooden crates and this is decided by the itinerant traders when they collect the produce from the village or at the farm gate. In addition, farmers choose the container when taking the produce to the market themselves.

The larger crates are the most common despite the difficulty in carrying them from the farms to the pick-up points (Lyon *et al.*, 1996). There is also the potential for post-harvest losses from the use of big crates as the sides are abrasive and the weight of the produce may crush tomato fruits at the bottom. Further more, heat of respiration generated at the centre of the big crate may likely accelerate deterioration where heat dissipation is poor. These assertions are reflected in the attitudes of retailers when a loaded vehicle arrives at the wholesale market. Older and more experienced traders usually stay away from the big crates and only go in for the smaller ones. Perhaps, due to the same reasons they would go in for crates other than those beneath or at the bottom of the vehicle. It is for a simple reason that small crates have been observed to contain more sound produce and that those crates beneath or under the others suffer squashing of the produce due to bad stacking.

Handling in the markets is done by porters (head load), trolley pushers, taxis, *"trotro"* (a sixteen to twenty seater mini bus) etc, who take the crates to the retailers. In the Kumasi Central Market this is usually carried out by the Gao ethnic group from Mali who have built up close relationships with some of the traders in the market. For distant markets such as Bola, Race Course, Asafo Market etc. in the Kumasi Metropolitan area, the means of transport include trolley pushers, taxis, *"trotro"* ,etc. The same situation exists in the Bolgatanga Markets.

Those selling in local markets may take the produce from the farm gates in baskets, either by headload, taxi, trotro, trolley pushers or otherwise. This usually results in a greater amount of produce being damaged as the baskets sit on top of each other.

The majority of the retailers were in favour of or were satisfied with the wooden crate being used presently. Clark (1994) stated that traders might not want to change as they were used to them. His statement was confirmed by some of the respondents who indicated that they might not want to change the units of sale as they have developed the skills in calculating profit and any different unit would mean a risk in mis-calculating the price. Lyon *et al.* (1996) stated that the most common containers used were the wooden crates and their use was decided by the itinerant traders (wholesalers) when they would collect produce from the village or from the farm gate. Some other section of the retailers recommended a reduction in the size of the wooden crate. This may be the opinions of those with very small capital which reduces their chance of buying more fruits for retailing.

Traders who were in favour of the stuffing of tomato crates may at least have had access to retailing produce from Burkina Faso. This is because an interrogation with a wholesaler from Burkina Faso in the Kumasi wholesale market on the issue of stuffing

indicated that grasses are used to block part of the ventilation gaps in the crates to prevent the smaller sized tomato fruits from dropping. Crates presently used have not been standardized in their construction.

Retailers confirmed that damages ranging from crushing, softening, rotting (deterioration) to different forms of cuts, bruises and scuffs occurred after transportation. Ellis *et al.* (1997) had indicated that the causes for these damages were attributable to poor stacking, heat from the sun, poor handling and transportation, poor ventilation in crates and vehicles, breakdown of vehicles, unsuitability of some of the vehicles for the business, poor road net-work, pests and the distance from production areas. The damaged tomato fruits were handled in several ways. Some of the retailers collected the seeds which they would later sell to the farmers. Others would sell the damaged fruits at very reduced prices to "chop bar " (local restaurant) operators for food preparation. Totally rotten ones are usually thrown away at the waste disposal dumps (Lyon *et al.*, 1996).

Kwaa (1994) asserted that the tomato fruits are wasted when grown abundantly during the rainy season that is from August to October, and in such times the prices would be significantly low . Yet no preservatives were available to traders to extend the shelf-life of the fruits.

The rate at which retailers dispose off produce would, however, be influenced by the season, supply, demand, the financial status of the trader and other marketing abilities and strategies the retailer exercises. They sorted produce into at least low quality produce called "percheir" in the Kumasi area markets and "potopoto" in the Bolgatanga area markets which would be cracked/punctured to the extent of exuding juice and seed or would be too soft to stand any little pressure. The unit of sale at the

retail level was by both volume and quantity. Lyon *et al.* (1996) reported that some retailers would put the produce on a table outside their houses (in groups of singles or in containers) or send a young girl to hawk the fruits from house to house.

Generally, retail packages encountered during the survey included black and white polyethylene bags, plastic buckets/baskets/bowls and used paint – tin or plastic containers. Common in the Kumasi area markets were also small woven baskets made from cane and palm fronds. In the Bolgatanga areas similar smaller baskets rather made from guinea corn stalks in addition to stuffed old kitchen bowls were found to constitute some of the pre-packaging containers at the retail level.

The risk of marketing tomato fruits is related to the perishable nature of the crop, the inability to store the produce and the poor information system that allow gluts to occur in certain producing areas and markets on certain days. Also the physical marketing structures are permanent although there has been large scale unplanned expansion of the markets making them highly congested and over crowding. This is especially the case in Kumasi and Bolgatanga area markets.

Most of the selling is carried out in the direct sun leading to deterioration. Traders may have to store produce in the markets when there is a glut or when trading has been slow. Fruits might be stored for only a few days as only small quantities of the produce can be put under the stalls.

Storage might be either in the store-rooms or in the open and sometimes under their sales tables. The produce is left in whatever the containers are (crates, baskets, pans, etc.) covered with jute sacks, fertilizer sacks made of polyethylene, plastic films, clothes, etc., after the day's sales. Storage by those who do not have a stall in the main market is limited to the quantity that they can carry home, unless they can have an

arrangement to leave the produce in a secure place such as a neighbouring shop. No traders were found to be using cold storage except for very small quantities in domestic fridges.

The unit price per crate is usually a shared decision within a group comprising the market queen, the wholesalers, retailers and the association chairmen/chairpersons. However, prices that have been agreed upon are subject to negotiations depending on the individual seller. The season of production in relation to supply and demand also do play a role in price setting.

5.1.3.3 SOCIO-ECONOMIC STATUS OF RETAILERS

Clark (1994) reported that the dominance of women in the retail trade sector is primarily due to unemployment. As such, most of them lack adequate capital to enable them trade. This may also be the reason why the majority of them traded on credit. The major restriction for both farmers and traders in the up-take of post-harvest and marketing innovations is the access to credit (Lyon *et al.*, 1996). However, a few of them indicated that they had additional businesses as supplement. The latter may be possible because though tomato trading is lucrative, it is also limited. Other traders join the trading occasionally on a temporary basis, regardless of their original businesses.

The issues of great importance to the retailers included lack of capital, lack of adequate or enough sitting space during sales and lack of a place for keeping the unsold fruits after sales, seasonality of the produce, poor sales and more especially the high perishability rate of the fresh tomato fruits after commercial handling and transportation.

There is the need to take a significant look at the distribution system for fresh tomato fruits since it has a major impact on the post harvest problems of the tomato industry. Any post harvest technique directed to improving the quality and extending the shelf – life of fresh tomato fruits must therefore be targeted at the wooden crate which is commonly used for bulk distribution.

5.2 EXISTING WOODEN CRATE EVALUATION

Discussion on the existing wooden package evaluation was done under the following sub-topics.

5.2.1 CRATE DIMENSIONS, EMPTY CRATE VOLUME AND EMPTY CRATE WEIGHT

The resulting dimensional measurement differences peculiar with the small crates (Table 47) might be due to the fact that the small crates were manufactured in lower numbers as compared with the big crates. Because the big crates are manufactured in greater numbers, the carpenters might be more conversant with their dimensions than those of the small crates. In the interview with the traders, it was revealed that traders preferred using the big crates.

On the basis of source/location of the crates (Table 47), the resulting dimensional measurement differences could be from the fact that traders from Tono and Vea might have bought their crates from a source different from the source of the crates transported from Akumadan and Agogo. Mitra (1997) stated that a good package must be readily available, preferably from more than one person or from a reliable supplier at an acceptable cost.

The significant measurement differences ($P<0.05$) found in the volume capacities of the small crates transported from Akumadan and Agogo is expected, as it is a

reflection of the dimensional measurements indicated in Table 47. The volume values were derived from the dimensional measurements. There were, however, no significant differences (P>0.05) in volume among the big crates across the four locations (Table 48), probably for the same reason outlined earlier in favour of volume values indicated for the small crates.

The absence of significant differences (P>0.05) in empty crate weight measurements among the different crate sizes was probably because the crates sampled were either all new crates or all old crates. The new crates are usually heavier as they are usually made from fresher timber. The weight diminishes as the timber ages. Therefore the uniform weight of the crates could mean that they were all freshly manufactured or have all aged before.

Generally lack of package standardization is responsible for all these measurement differences. Ellis *et al.* (1997) stated that in Ghana, like other West African countries, the packaging industry is not as highly developed as that of the developed nations. Schuur (1988) earlier on had stated that a number of non-standardized sizes of package are in use all over the world but that the International Standard Organization gives a series of dimensions for rigid rectangular packages based on a standard plan dimension or module of 600 x 400mm as the external size (length x width) of a package unit when fully loaded.

Standard dimensions facilitate economic use of materials, offer adequate strength and allow easy and secure handling, loading and stacking (Wills *et al.*, 1998). They stated that in modern packaging, dimensions are both economically and structurally of great importance and that the optimal length to width ratio for rigid rectangular packages based on a standard plan should be about 1.5:1 as the external size of the package unit

when fully loaded. They also indicated that thirty litre (about 20kg of produce) and fifteen litre (about 10kg of produce) packages are becoming standard for fruits with larger thirty-six litre (about 24kg of produce) packages being used for some vegetables.

It can be inferred from Table 47 that the mean external length to the mean external width ratios for the small as well as the big crates across the four locations were 1.3:1 and 1.4:1 respectively. These ratios are both below standards as compared with recommendations by Wills *et al.* (1998). From Table 49, the results also show that the mean weights of the small as well as the big crates, when fully loaded, across the four locations were about 68kg and 90 kg respectively. Again these values are far above standard as compared with the recommendations by Wills *et al.* (1998). The results obtained so far therefore suggest a review of the dimensions, volume and weights of both the small and big crates presently used for the transportation, distribution and marketing of fresh tomato fruits in the country. Thus, small sized crates are recommendable.

5.2.2. DISTRIBUTION OF VARIOUS TYPES OF DAMAGED TOMATO FRUITS IN DIFFERENT PACKAGE SIZES AFTER TRANSPORTATION

The comparatively higher damage associated with the big crates was probably due to a higher likely compression damage that would have resulted in squashing and bruising of fruits at the bottom of the big crates as compared to the small crates. Another reason might be the possible incidence of higher levels of respiratory and subsequent heat that would be produced near or at the center of the big crates as a result of excessive volume of produce (Bonte-Friedheim, 1989). Gould (1983) who earlier reported on different sizes of bulk boxes for handling tomato fruit, indicated that as the depth of the box increased injury expressed as cracked fruit also increased. The

higher level of damages in the big crates may also be associated with the high amount of mechanical and physiological damages in the big crates since there were significant correlations (r=0.76* and r =0.86*) between crate size and each of mechanical and physiological damages respectively.

The much higher amount of sound fruits in the small crates transported from Akumadan and Agogo on percentage basis was probably due to the short distances covered from the two locations/sources (96km and 51km respectively) to the Kumasi wholesale market as compared to the longer distances (576 km and 546 km) covered from Tono and Vea respectively. This is also reflected in the amount of fruits recorded as completely squashed with respect to crate size and source, in which the amount was significantly ($P<0.05$) higher in the big crates than in the small crates.

The higher amount of sound fruits in the small crates could also be as a result of the fact that such crates could comparatively be reasonably lifted and carried during loading and off-loading as compared with the big crates, thus enhancing better quality produce. This assertion also agrees with Buel (1986) who stated that for convenience the package size might be dictated by what a person can reasonably lift or carry.

The significantly ($P<0.05$) higher amount of damaged fruits transported from Tono and Vea as compared to those from Akumadan and Agogo might be due to the bad roads and the longer distances encountered from Tono and Vea farm-gates to the Kumasi wholesale market, 575 km and 546 km respectively compared with only 96 km and 51 km from Akumadan and Agogo respectively. The difference, with regard to location or source could also be the result of the harsh weather conditions which were harmattan, high ambient temperatures (42^0C), and low relative humidity (30%)

prevailing at the time of the experiment (ICOUR LTD, 1995) peculiar with the Upper East Region which could have caused some wilting effects in some of the fruits.

Generally these losses might be due to the high injuries sustained as a result of loading pressures and fruit impact with the wooden crate container and with each other during transportation over the distances and rough roads. Poor handling during harvesting, loading and unloading; poor packaging practices, break down of vehicles and the high ambient temperatures (42^0C) under which the tomato fruits were kept in the crates for several hours, at both the farm-gate and wholesale market, may also have contributed to these damages.

Irrespective of treatment and the source of the tomato fruits, physiological damage accounted for most of the damaged samples whilst pathological damage was the least important (Table 49). The physiological damages may be due partly to poor harvesting methods and handling; also the prevailing harsh weather conditions could have caused some amount of wilting effects in some of the fruits as already indicated. It could also be as a result of the traditional practice of packaging the pathologically affected and the ripened tomato fruits in the same container for transportation. This often encourages the ethylene gas emitted by both pathologically affected and the ripened tomato fruits to trigger off tissue softening and increase damage with its associated problems (Aworh and Olorunda, 1981). Also excessive volume of produce as a result of the enormous size of the crate as well as exposure of packages to external heat could have possibly necessitated the incidence of respiratory heat to be generated or produced near or at the center of the package thus enhancing over ripening, softness, wilts and subsequent physiological damages.

The practice of mix-loading could also enhance high level of physiological damage. Tindall (1983) stated that with mixed storage or mixed load of different commodities,

ethylene produced from ripening fruit can promote rapid senescence in the fresh tomato fruit.

Post-harvest physiological disorders are mostly injuries due to temperature and controlled atmospheres, mainly carbon-dioxide and oxygen levels – the others include relative humidity and ethylene effects (Lieberman, 1983).

Bonte-Friedheim (1989) indicated that exposure of packages to external heat e.g. direct sunlight or storage near heating systems, and natural build up of internal heat of produce owing to poor ventilation within package in storage or vehicle can have major deleterious effects like over ripening, softness, wilts off-flavours, rots, etc. He also associated the causes of overheating in fresh produce to include the use of closed vehicles without ventilation; close-stow stacking patterns blocking the movement of air between and through packages, thus hindering the dispersal of heat; the lack of adequate ventilation of the packages themselves; and exposure of the packages to the sun while awaiting transport or while trucks are queuing to unload at their destination also lead to overheating.

The mechanical damages suffered by the packaged fruits might be due to cuts and cracks through careless handling, punctures from piercing objects like protruding nails and splinters in the crate in question and scuffs from abrasions against the rough surfaces of the crate. Other likely causes of mechanical damage might be impacts against hard surfaces like throwing and dropping of packages, sudden starting and stopping of vehicles carrying packaged tomato fruits. Excessive pressures e.g. in over-sized containers, over-filled containers or containers stacked too high or both, collapse of stacked containers during transport or weak packaging could cause damages. Vibration bruises through repeated and prolonged vibration of fruits against adjacent

surfaces, vibration of the vehicle itself and from rough road or bad shock absorbers, as well as transmission vibration causing jerking due to poor fuel transmission (Bonte-Friedheim, 1989) could also cause damages. Mechanical defects were found to be significantly higher ($P< 0.05$) in the big crates than in the small crates (Table 49). The reason may be that the big crates are more prone to the above mentioned hazards associated with mechanical damage.

Boyette *et al.* (1996) indicated that packaged fruit and vegetables vary widely in their susceptibility to mechanical damage and in the types of mechanical injury to which they are susceptible. They added that for packaged fresh tomato fruits, two types and various causes of mechanical injury to produce can be identified – they are open wounds and bruises. According to Mitra (1997) inappropriate packaging may cause mechanical damage of the produce due to bruising or abrasion as the commodity moves about during transport. He indicated that both under-filling and over-filling are to be avoided so that individual items are held firmly, but not too tightly within the package.

The relative susceptibilities of fresh tomato fruits were also shown by Guillen (1964). He indicated that tomato fruit at mature green is less susceptible to impact and vibration than compression, while pink or ripe fruits are only less susceptible to vibration.

The least pathological defects recorded may be attributed to the low relative humidity existing at the time of the experiment which might have inhibited the growth of micro-organisms. The few pathological defects might have been the results of some susceptible physiological and mechanical damage points which acted as entry points for rotting fungi and bacteria. This assertion agrees with Tindall (1983) who indicated

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that many of the mechanical and physiological hazards of packaging inflicted on fresh produce are aggravated by pathological breakdown resulting from rotting fungi and bacteria. Another possible means by which packaged tomato fruits could be pathologically infected might be the result of the traditional practice of packaging the pathologically affected and the ripened tomato fruits in the same container for transportation. Perhaps improvements in the design and construction of both the small and the big size crates might in the context of the small-scale trader prove to be a better solution to the abundant losses incurred.

5.2.3 QUALITY CHARACTERISTICS OF PACKAGED TOMATO FRUITS FOR THE FRESH MARKET

Fruits transported from Tono and Vea had significantly ($P<0.05$) shorter shelf-life of about 4 days compared to those transported from Akumadan and Agogo (about 6 days) (Table 50). This finding is in line with that of Olympio *et al.* (1998). They indicated that the tomato fruit is versatile in its usage but as a vegetable it is highly perishable, spoiling within 4-6 days if harvested at the red-ripe stage under ambient temperatures, depending on the variety and leading to huge economic losses for farmers, traders and consumers alike. The significant decrease in shelf-life might be the result of rapid softening of fruits caused by bad roads and the longer distances encounted from Tono and Vea farm-gates to the Kumasi wholesale market. Gould (1983) indicated that mechanical damage offer entry points for pathogens. Thus as fruits sustain cuts and bruises through various mechanical damages they become more and more susceptible to microbial infection and therefore have shorter shelf-life.

Rots caused by micro-organisms have been reported by some authors to constitute up to 50% losses in fresh tomato fruits after harvest (Olukumbi and Fabiyi, 1987; Erinle, 1989). However, some consumers accept cracked fruits provided they are fresh, big

and brightly coloured. Another likely reason for the decrease in shelf-life could also be the result of the more harsh weather conditions (harmattan, high ambient temperatures and low relative humidity) peculiar with the Upper East Region at the time of the experiment which could have caused some wilting effects in some of the fruits.

Atherton and Rudich (1986) stated that for successful mechanization of the tomato industry, the most important characteristic is a concentrated set of firm tough fruits.

Fruits in the small crates were significantly ($P<0.05$) firmer (Table 51) probably, because of their smaller sizes and for that matter lesser fruits content or lesser produce volume, the likely compression force that was exerted on the fruits below or at the bottom of the crate by those at the top was less as compared to the strength of compression force exerted in the big crates. This assertion is supported by Gould (1983) who reported that as the depth of the box increased, fruit injury expressed as cracked fruit also increased. Thus, the size of a crate as well as its convenience of handling, play an important role in protecting the quality of fresh produce. Another likely reason is that the possible incidence of respiratory heat produced near or at the center of the package as a result of excessive volume of produce might be minimal in the small crates as compared with the big crates.

According to Grierson and Kader (1986), temperatures above 30^0C are equally injurious and that fruits in a package exposed to such temperatures become soft prematurely. However, El-Sayed and Erickson (1966) reported that fruit firmness had been found to be under genetic control whilst Rama-Rao and Choudhury (1974) also found a single gene coupled with a number of minor or modifier genes with complete dominance controlling softness in the tomato fruit.

Firmer fruits transported in the small crates are likely to store longer than those relatively soft fruits transported in the big crates. The small crates are therefore comparatively suitable for transporting tomato fruits for the fresh market where longer distance shipment is involved as already indicated by other workers. For instance Beattie *et al.*(1983) indicated that firm fruits (tough skin and firm flesh) are less susceptible to physical and mechanical damage and therefore store better and enhance transportation and distribution in the marketing system.

Different crate sizes recorded significantly ($P<0.05$) different mean fruit weights, likewise the four different sources (Table 52). The differences might be attributed to the lack of adequate sorting and grading during packing of the fruits at all the four farm-gates, which was indicated by the farmers and traders during the survey.

It was observed personally during the survey that farmers packed any size of tomato fruit into any crate (small or big). The smaller fruits were usually particularly packed underneath the pile, with the bigger ones at the top so as to attract customers. In other circumstances, packing the smaller fruits below the bigger ones was usually a directive or command given to farmers by the traders. However, the relatively bigger fruits are more acceptable to the Ghanaian fresh market as compared to the smaller fruits since most consumers in Ghana prefer bigger fruits to smaller ones.

The insignificant differences ($P>0.05$) in the pH, percent titratable acidity, percent total soluble solids and ascorbic acid content of the fruits after transportation (Table 53) imply that the are neither influenced by any of the different crate sizes nor any of the different sources from where the fruits were sampled. The values however, fell within the range recommended suitable for fresh tomato fruit quality. Villareal (1980), Gould (1983) and Norman (1992) indicated 4.4, 3.7-4.6 and 4.0-4.5

respectively as suitable pH range values for good tomato fruit quality. Lambeth *et al.* (1966) indicated that there is a tremendous variation among tomato genotypes for pH and titratable acidity. In a study of 250 tomato accessions the authors found that there was a variation in pH from 4.26 to 4.82 and percentage citric acid ranged from 0.40 to 0.91%. Low pH is a desirable quality characteristic in tomato fruits as reported by Aworh *et al.* (1982) and that it reduces contamination by *Clostridium botulinum*.

The pH of a fruit extract is one way of expressing the acidity of a fruit but one cannot always find a correlation between pH and titratable acidity of any particular fruit (Kwaa, 1995). The tomato fruit is thus an acid food since the average pH found in most cultivars is around 4.0 (Villareal, 1980).

High titratable acidity is generally an indicator of good quality tomato fruit (Efiuvwevwere and Uwanogho, 1990). In this study it was realized that even though there were no significant differences ($P>0.05$) in percent titratable acidity for all treatments across the four locations after transportation, the overall percent titratable acidity range (0.48 to 0.65) Table 53 was within the range recommended suitable for the fresh market (Agble, 1971; Gould, 1983; and Norman 1992) which is known to be from a minimum of 0.35 to a maximum of 0.55. Agble (1971) screened 21 tomato varieties and reported their acidity to be between 0.41 and 0.71%.

The total soluble solids content of tomato fruits is important both from the standpoint of product consistency and processing, as well as the quality of the fresh produce (Gould, 1983). Opena (1983) also indicated that high value of total soluble solids is desirable because it relates to the yield of processed products. However, the results in Table 53 show that there was no significant difference ($P>0.05$) in the total soluble solids content of the tomato fruits in all the treatments across the four locations after

transportation. But the overall range of total soluble solids values was 3.5 – 4.6%. These values according to Agble (1971), Gould (1983) and Norman (1992) are within the range recommended suitable for the fresh market. For Agble (1971) and Norman (1992) the recommended value is 4.5% and above, while Gould (1983) recommended a minimum of 5.5% and above.

As indicated earlier, there were no significant differences ($P>0.05$) in the ascorbic acid content of fruits as regard all the treatments across the four locations after transportation (Table 53).

A significantly ($P<0.05$) lower ascorbic acid content in fruits obtained from Upper East Region (Tono and Vea) compared to those from the Ashanti Region (Akumadan and Agogo) was expected. This expected difference could be due to the longer hours spent in transit in transporting the produce from the Upper East Region to the Kumasi wholesale market as compared with the shorter journeys within the Ashanti Region to the same wholesale market. This is also supported by Salunkhe *et al.* (1991) who stated that loss of ascorbic acid can occur during handling in the raw state. The difference may also be due to the effect of the semi-arid temperatures (high temperatures and low relative humidities), which might have accelerated the conversion of ascorbic acid to oxidized forms. They added that losses of ascorbic acid are accelerated by high temperatures and high rates of wilting.

Generally, the extent and rate of oxidation of ascorbic acid is affected by the time, temperature, oxygen availability, pH, the vitamin concentration, extent of cell damage and the presence of oxidative enzymes (Mapson, 1970; Bradley, 1972). Upon oxidation ascorbic acid loses two atoms of hydrogen to yield dehydro – ascorbic acid which has reduced nutritional quality (only 75% of the antiscorbutic activity)

(Akinbolu *et al.*, 1990). The dehydro – ascorbic acid is then relatively unstable and easily undergoes an irreversible reaction to produce diketo-L-gulonic acid, which has no antiscorbutic activity at all (Krochta *et al.*, 1975). However, Bradley (1972) reported that the degradation of ascorbic acid is retarded significantly in sugar solutions.

Krochta *et al.* (1975) indicated that the retention of ascorbic acid is an index of quality and nutritive value in fruit and vegetables. The range of ascorbic acid values across the different treatments and locations was 19.89 to 25.60mg/1000g fresh weight (Table 53). These values, however, agree with the findings of Akinbolu *et al.* (1990) who evaluated postharvest losses and quality changes in the tomato and obtained ascorbic acid content value range of 16.57-28.53mg/1000g fresh weight.

5.3 IMPROVED WOODEN CRATE EVALUATION

5.3.1 CRATE DIMENSIONS, EMPTY CRATE VOLUME AND EMPTY CRATE WEIGHT.

The significant difference in dimensional measurements between the big and the small crates is what is expected as empirically expressed (small and big) (Table 54). But the producer sector of the tomato industry (i.e., the farmers) are not too happy about the prevalence of the small and big crates in the market chain when it comes to quantity and price determination. This is because even though the two different sizes are both patronized, the small one is not actually one-half of the big one in quantity as the traders consider it. This assertion was observed by Clark (1994) who reported that traders discourage farmers from using the small crate by paying only half the price of the big crate for it even when it is more than half the quantity of the big crate.

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For the difference in the dimensional measurements particularly between the big and improved crates, principles and recommendations on appropriate packaging were considered in favour of the improved one. This follows the results of the evaluation of the small and big crates which revealed that they needed a review in construction.

The mean weights of the small and big crates when fully loaded across the four locations (68 kg and 90 kg respectively) (Tables 49 and 55) were far above those of the ILO standards of 20kg and 10kg for fruits and 24kg for some vegetables.

The mean volumes of all the small and big crates across the four locations ($0.092m^3$ and $0.144m^3$ respectively) also far exceeded the ILO recommendations. These may have led to the different types of damages that were inflicted on the fresh tomato produce during and after transportation. But Brennan *et al.* (1990) indicated that the function of a package is primarily to contain and protect the produce against a variety of hazards which might adversely affect its quality during handling, distribution and storage. Buel (1986) stated that the size of the package is so important that it should be designed in terms of the amount the market or customer requires in a single unit. In other circumstances the package design may be dictated by what a person can reasonably lift or carry in order to maintain produce quality.

The improved crate was designed to be smaller (Table 55) in order to protect the produce against a variety of hazards which might adversely affect its quality during handling, distribution and storage. Thus enhancing easy and secure stacking in lorries or stores and coupled with the planed inner surfaces and absence of protruding nails reduces damage to produce (Thompson, 1996).

The emphasis was that the newly improved crate should not be put on the shelves but be used in the market or be put into use. As such the size was made at least to be about that of the smaller crate, however, with recommended standardized construction.

This is because the tomato industry in Ghana is not very well developed and the stakeholders (farmers and traders) were more interested in larger volumes and quantities rather than quality. And so they prefer larger containers that convey more produce and attract more damages to smaller containers that convey lesser produce with good quality, as reported by Clark (1994) and Lyon *et al.* (1996). This has been the order of the day, probably because they have always been able to sell the damaged fruits, beside other reasons already discussed such as a reduction in the amount paid on levies per crate. Ellis *et al.* (1997) in their review of some packaging materials/techniques used in Ghana indicated that in Ghana, like other West African countries, the packaging industry is not as highly developed as that of the developed nations thus information on packaging techniques in terms of statistics is not easily available. Therefore, the next target would be to dwell on educating the stakeholders on packaging and its consequences from pre-harvest to post-harvest.

5.3.2 DISTRIBUTION OF VARIOUS TYPES OF DAMAGED TOMATO FRUITS IN DIFFERENT PACKAGE SIZES AFTER TRANSPORTATION.

The improved crate recorded a significant ($P<0.05$) higher percentage (91%) of sound fruits (Table 56) because its construction was guided by some principles of appropriate packaging and other recommendations by the ILO as indicated by Wills *et a*l. (1998) to enhance good produce quality. The standard dimensions offered adequate strength and allowed easy and secured handling, loading and stacking, while the inner surfaces were also planed and was without protruding nails. Thompson (1996) also indicated that non-standard sizes can make crates difficult to stack on lorries or in stores, and often-unplaned inner surfaces or protruding nails can damage produce.

A further important requirement of packaging necessary to allow rapid cooling of produce was also considered in the construction of the improved crate i.e. about 5% of

the surface area of the crate was allowed to enhance adequate ventilation (Schuur, 1988).

Ideally, respiratory heat should be able to escape readily from the package. Thus the volume of the contents, being the minimum dimensions of the package from the center to the surface becomes a critical issue. This is because, if the volume of the package filled with produce is excessive, produce near or at the center of the package will heat up because respiratory heat cannot dissipate fast enough under such a condition. Metabolism becomes abnormal then, and this would result in a break-down of membrane integrity and structure with disruption of cellular organisation and rapid deterioration of the produce (Wills *et al.*, 1998). To curb this situation, a middle plate was provided and the volume of the crate was divided into two equal parts. Each part was allowed a pack of only 5 layers, as recommended by UNDP/FAO/MOFA (1988). The provision of the middle plate also checked the likely compression damage that would have resulted in squashing and bruising of tomato fruits at the bottom of the crate (Gould, 1983).

It has been reported that bruising and squashing occur only when tomato fruits are packed above five layers, i.e., a height of more than 180mm (UNDP/FAO/MOFA, 1988). But, Tweneboah (2000) indicated that for ripe tomato fruits the maximum appears to be 3-4 layers. The five layer design was instead considered and used in this experiment to prevent the new crate from being left unused, since the stakeholders in the tomato industry in Ghana are rather more interested in larger volumes and quantities than quality.

Two wooden bars each of a height of 2cm were also provided at the top of the crate near the extremes to reduce damage to the fruits when the crates are stacked. This agrees with Gould (1983) who reported that in Columbus, Ohio state, tomato fruits are

transported from the field to the processing factory in containers including lug boxes with varied capacities from 18-23 kg and a 2cm cleat on the top edge to reduce damage to the fruit when the boxes were stacked.

Alomenu (1992) and Kwaa (1994) recommended wooden packages for the tropics on the merits of its readily availability, its reasonable cost, the ease with which it can be worked, its rigid fibrous structure and the relatively slight effect of ambient climatic conditions on the rigidity.

The type of wood used was "*Oframu*" (*Terminalia superba*). However, according to Worth (1969), with the exception of "*Potrodom*" (*Erythrophlem ivorense*) (a type of timber) which may cause an unpleasant taste to produce when contained in it, several types of wood could as well be used depending on their conveniences. The type of wood used presently in the manufacture of tomato fruit crates in Ghana is "*Wawa*" (*Triplochiton scleroxylon*) which is heavier than "*Oframu*" (*Terminalia superba*) and strong only when newly constructed. As "*Wawa*" (*Triplochiton scleroxylon*) ages, it loses weight and becomes brittle resulting in an early collapse of the package unit. In this case the objective of market penetration and competitiveness is defeated for the crate (Schuur, 1988). "*Wawa*" (*Triplochiton scleroxylon*), takes a longer time to dry up after construction in order to maintain a constant weight and is also susceptible to insect damage. "*Oframu*" (*Terminalia superba*) is not susceptible to insect damage and it also dries up early even during construction of the crate. However, both types of wood ("W*awa*" and "*Oframu*") do not warp on exposure to any adverse condition such as absorption or loss of moisture (Amankwaah, 2002, personal communication).

A likely reason that might possibly explain why the small crate contained a significant ($P<0.05$) high amount of sound fruits as compared with the big crate (Table 56) could be for its small size that would have made its handling, loading and stacking easier

and secured as stated by Gould (1983), thus enhancing its content quality. Another possible reason could be that there might be less heat from respiration generated in it as compared to the big crate. Also the compression damage likely to occur within the tomato fruits would have been higher in the big crate than in the small crate.

The fact that physiological damage accounted for most of the damaged samples (Table 56) may probably be due partly to poor handling and harvesting methods. Metabolic stress is imposed on produce, which is exposed to excessive field heat during and after harvest, thus advancing general senescence (Wills *et al.*, 1998). They indicated that when temperatures of horticultural produce at harvest are high, respiratory rates are extremely high and storage life will be correspondingly reduced.

About 65% of the framers interviewed attested to the fact that they harvested only when the traders have arrived and a price has been agreed upon. As such harvesting is carried out at any time of the day, at the red-ripe stage.

5.3.3 QUALITY CHARACTERISTICS OF PACKAGED TOMATO FRUITS FOR THE FRESH MARKET.

The shelf-life of fruits transported in the improved crate was significantly ($P<0.05$) longer than those transported in the small and big crates (Table 57) since the improved crate was constructed upon all the possible means to ensure maximum quality after transportation. The criteria, principles and recommendations that were considered for its construction have been outlined and discussed earlier in 5.3.1 and 5.3.2. The improved crate is therefore recommended to ensure extended storage life of produce during and after transportation. The fruits in the improved crate were more protected by the container than those in the small and big crates, so that their firmness was maintained better compared to those of the small and big crates (Table 57).

However, fruits in the small crates were also significantly firmer than those in the big crates. These differences might also be better explained with reasons already discussed in 5.3.2. The improved crate is therefore more suitable for transporting fruits for fresh market where longer distance shipment is involved.

The differences in fruit weight that occurred among the different crate sizes (Table 57) are not attributed to the crates. The differences might be due partly to the lack of adequate sorting and grading at the farm-gate as discussed earlier in 5.2.3.

The bigger sizes of the fruits probably attributed partly to the significant ($P<0.05$) shorter shelf-life they recorded for fruits in the big crates as compared to the fruits in the improved crate, since there was a negative correlation ($r=-0.518^*$) between shelf-life and mean fruit weight of the fruits. However, the relatively bigger fruit sizes are more acceptable to the Ghanaian fresh market since most consumers in Ghana prefer bigger fruits to smaller ones.

It was observed that deterioration due to rot was more in fruits transported in the small and big crates than those transported in the improved crate. This might be due to an infection of these crates which affected the produce. This assertion complies with Pierce (1987) who stated that post-harvest diseases can be spread by field crates contaminated by soil or rotting produce or both. Meanwhile there is also the practice of packaging both over-ripened and pathologically affected produce in the same crate for transportation.

The rate of deterioration of fruits transported in the big crate was also observed to be faster than those transported in the small crate. This is expected since the comparative excessive volume of produce with respect to the big crate would have attracted a

higher compression damage, a highly generated heat of respiration and an inconvenienced easy and secure loading, handling and stacking, all of which enhance produce deterioration.

6.0 SUMMARY AND CONCLUSION

The study was carried out to evaluate and improve upon the existing packaging methods for marketing of fresh tomato fruits in Ghana. This was accomplished by conducting a survey, laboratory analyses, designing and developing an improved packaging unit.

The survey results obtained showed that there were two types of wooden crates, small and big, commonly used for bulk distribution of fresh tomato fruits from the farm-gate to the wholesale market. Locally woven baskets made from cane, palm fronds and guinea corn stalks were used only for very short distance transportation, and usually to the local markets.

It was also revealed that the major concern of the producers/farmers with regard to packaging was the standardization of the crate's volume and the stabilization of the unit price for a crate of tomato fruits. Post-harvest losses were not among farmers' priorities.

For the wholesalers and retailers, the high perishability rate of fresh tomato fruits during and after commercial handling and transportation was one most important issue of great concern, because of the lack of storage for fruits.

It was evident from the results obtained from the evaluation of the crates that for both the small and big crates, the mean constructional dimensional measurements particularly the length to width ratio was below the standards as recommended by the ILO. The evaluation revealed further that the mean weight and mean volume of each of the small and big crates when fully loaded, were far above the standards

recommended by ILO, which resulted in consequent loading, handling and stacking problems. Fruits in the small crates remained significantly ($P<0.05$) less damaged (56%) than those in the big crates (62%) in terms of weight.

This made the small crates more effective as compared to the big crates. Damages were also higher in crates transported from longer distances when compared to similar ones transported from shorter distances. Irrespective of crate size and the source of the tomato fruits, physiological damage accounted for most of the damaged samples, whilst pathological damage was the least important.

The evaluated results also indicated that tomato fruits transported in small crates were significantly ($P<0.05$) firmer and had longer shelf-life as compared to those transported in the big crates. This enhanced a comparative advantage of the small crate over the big crate where longer distance shipment and the maintenance of quality characteristics for the fresh market was concerned. It was also observed that quality characteristics for processing fresh tomato fruits such as pH, percent titratable acidity, percent total soluble solids, percent reducing sugars and ascorbic acid content were not significantly ($P>0.05$) affected by the crate sizes evaluated.

The designed and developed crate was also evaluated just as the crates in current use were. The results indicated that only 9% damaged fruits by weight were recorded compared to the 56% recorded for the small crates.

The following recommendations are proposed. The improved crates should be further evaluated in other parts of Ghana using similar vehicles and other varieties of tomato. A pilot project including an educational programme should be conducted with farmers, wholesalers and retailers on packaging, transportation and general handling using the improved crate.

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APPENDIX

APPENDIX 1: DRY AND RAINY SEASONAL DISTRIBUTION IN NORTHERN GHANA

TYPE OF SEASON	DURATION OF SEASON
Rainy Season	April to October
Dry Season	November to March

NB: The seasonal distribution (Appendix 1) holds for only Northern, Upper East and Upper West Regions of Ghana.